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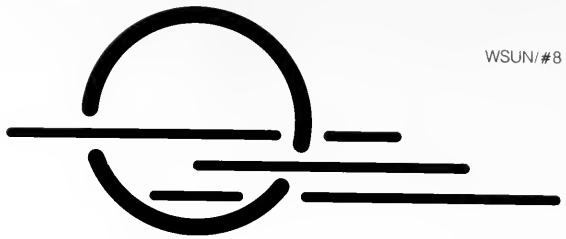

MONTANA

SOLAR and WEATHER INFORMATION

One in a series of thirteen climate data manuals for the states of the Western Region.
Western SUN/Suite 800, 715 S. W. Morrison, Portland, Oregon 97205

ACKNOWLEDGMENTS

This solar and weather assessment was compiled for Western SUN in an effort to reference in one source the type of data most important to the solar system designer and user. The data contained in this publication was gathered and processed for Western SUN by R.W. Durrenberger, climatologist for the Solar and Atmospheric Research Associates (SARA). The data is primarily based on material from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). The station summaries are all official NOAA documents written by the local weather monitoring officials.

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September/1980

CONTENTS

INTRODUCTION

This work represents the first regional effort to gather, collect and present for the solar energy system user, a climate and solar radiation data resource. The need for good, highly usable solar radiation data is great, and in the Western United States data stations are normally far apart.

While it is acknowledged that the field of solar radiation data is changing rapidly as new stations are installed or methodologies developed, the need for good well-tabulated data has been a repeated one in our region. This manual is presented as our first effort at dealing with this need.

To Use This Manual

This manual is one of thirteen such data sets. Each manual has been developed for one specific state. Each state has been divided into a given number of climate zones. These zones encompass regions of the state which have climate patterns similar in nature; that is, patterns of temperature occurrence, solar radiation data, etc. which are generically identical.

To use this manual, find the climate zone in which your site exists. If your site is not represented by a station, then use the data for the geographically closest station in that zone. Crossing zones should be done only if the user is familiar with the climate and solar data of both sites and is sure that they are truly similar.

The information presented consists of meteorological data such as temperature, heating and cooling degree days, etc. Solar radiation data has been processed into tables giving values for energy on tilted surfaces, both south facing and oriented off south.

ABBREVIATIONS, UNITS and GLOSSARY

AFM-88-20: Air Force Manual of Engineering Weather Data for Facility Design and Planning.

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

BTU: British Thermal Unit.

BTU/FT²: BTU's per square foot, equals KJ/M² times 0.088114.

DESIGN TEMPERATURE: The assumed worst case outside temperature used by engineers to calculate the maximum heating or cooling load of a building and for sizing heating and cooling equipment.

DIFFUSE INSOLATION: Incident solar radiation which comes to the incident surface after being scattered and reflected by the dust, water vapor and gas molecules in the atmosphere.

DIRECT (BEAM) INSOLATION: Incident solar radiation coming directly from the sun to the incident surface.

EXTRATERRESTRIAL INSOLATION: The incident solar radiation received on an incident surface at the top of the earth's atmosphere. For the special case when the incident surface is also normal to the sun's rays the amount of insolation received is referred to as the solar constant (429 BTU/FT²-Hr.). The solar constant varies by about ± 3% due to the difference in distance from the earth to the sun during winter and summer.

INCIDENT SURFACE: The surface which finally receives and collects the incoming solar radiation.

INSOLATION: *In*cident *sol*ar radi*ation.*

KJ/M²: KiloJoules per square meter.

REFLECTED INSOLATION: Incident solar radiation which is reflected off other solid surfaces before coming to the incident surface.

ROOF ANGLE:

Slope	Angle(±)
2/12	9°
3/12	14°
4/12	18°
5/12	22°
6/12	26°
7/12	30°
8/12	33°
9/12	37°
10/12	39°
11/12	42°
12/12	45°
13/12	48°
14/12	50°
15/12	52°
16/12	54°
17/12	55°
18/12	57°
19/12	59°
20/12	60°

EXPLANATION of TABLE HEADINGS

AVERAGE DAILY MAX. TEMPERATURE: Average of the highest daily temperatures for the month in degrees Fahrenheit. Based on the period from 1941 to 1970.

AVERAGE DAILY MIN. TEMPERATURE: Average of the lowest daily temperatures for the month in degrees Fahrenheit. Based on the period from 1941 to 1970.

AVERAGE MONTHLY TEMPERATURE: Average monthly temperature in degrees Fahrenheit. Based on the period from 1941 to 1970.

DIRECT BEAM NORMAL INCIDENCE: The incident solar radiation coming directly from the sun which falls on a surface which is tracking the sun's position. This is a calculated value. Diffuse and reflected solar radiation is not included.

DIRECT BEAM + DIFFUSE: The sum of the direct beam, insolation and the diffuse isolation, both corrected for orientation and tilt. The values are in Btu per square foot for the entire day.

ELEVATION: The elevation of the location in feet above sea level.

LATITUDE: Latitude in degrees and minutes.

LOCATION: Name of airport or city where data was observed.

LONGITUDE: Longitude in degrees and minutes.

MEAN CLOUD COVER: An observational estimate of the amount of cloud cover expressed as a non-dimensional number from 0 to 10. 10 indicates a sky fully covered with clouds and 0 a clear sky.

ORIENT: The orientation of the incident surface. This value is in degrees of variation away from solar south, toward either the east or the west. Solar or true south should not be confused with magnetic south which can vary by as much as 25 degrees due to the magnetic declination.

PERCENT OF POSSIBLE SUNSHINE: The actual number of hours of sunshine divided by the maximum possible number of hours of sunshine expressed as a percentage for the month.

PERCENT RELATIVE HUMIDITY (Night): The average night time relative humidity for the month. This would be close to the average of the highest relative humidities experienced each month.

PERCENT OF TOTAL HORIZONTAL TO EXTRATERRESTRIAL INSOLATION: A ratio of the monthly averaged, horizontal, terrestrial insolation to the monthly averaged, extraterrestrial, horizontal insolation. This calculated value is expressed as a percentage.

REFLECTED: The solar radiation reflected from a flat horizontal surface at the bottom of the titled incident surface. These values are in Btu per square foot of incident surface for the entire day. The reflecting surface is assumed to be semi-infinite.

REFLECTIVITY: A non-dimensional number which indicates what fraction of the solar radiation striking a reflective surface is actually reflected. RHO is a symbol for reflectivity.

TILT: The tilt of the incident surface toward the south from horizontal. This value is in degrees up from horizontal.

TIME ZONE: Time zone of the location (i.e. Eastern, Central, Mountain, Pacific, etc.)

TOTAL COOLING DEG-DAYS FOR THE MONTH: The cumulative total number of degrees Fahrenheit above 65°F for the entire month.

TOTAL HEATING DEG-DAYS FOR THE MONTH: The cumulative total number of degrees Fahrenheit below 65° F for the entire month.

TOTAL HORIZONTAL INSOLATION: The total hemispheric mean daily solar radiation incident on horizontal surface. A measured or estimated value which includes both downward direct and diffuse solar radiation.

TOTAL SOUTH WALL INSOLATION: The total incident solar radiation on a due south wall. This calculated value includes direct, diffuse and reflected solar radiation. The constant ground reflectivity was assumed to be 0.2.

WIND DIRECTION: This is the primary direction from which the wind most often comes.

WIND SPEED: The monthly average wind speed in miles per hour.

WINTER/SUMMER DESIGN TEMPERATURE: The ASHRAE 97.5% winter design dry-bulb and the ASHRAE 2.5% summer design dry-bulb temperatures in degrees Fahrenheit. Some values are from AFM-88-20.

CLIMATE ZONES

ZONE 1: Coastal Mountains and Valleys

a. North Pacific Coast
b. Central Pacific Coast
c. Southern California

ZONE 2: Interior Valleys

a. Puget Sound/ Willamette Valley Lowland
b. Central Valley of California

ZONE 3: High Mountains

a. Sierra Nevada/ Klamath
b. Cascades
c. Northern Rockies
d. Southern Rockies
e. Wasatch/Rim Country
f. Mogollon Rim

ZONE 4: Columbia Plateau

ZONE 5: Great Basin

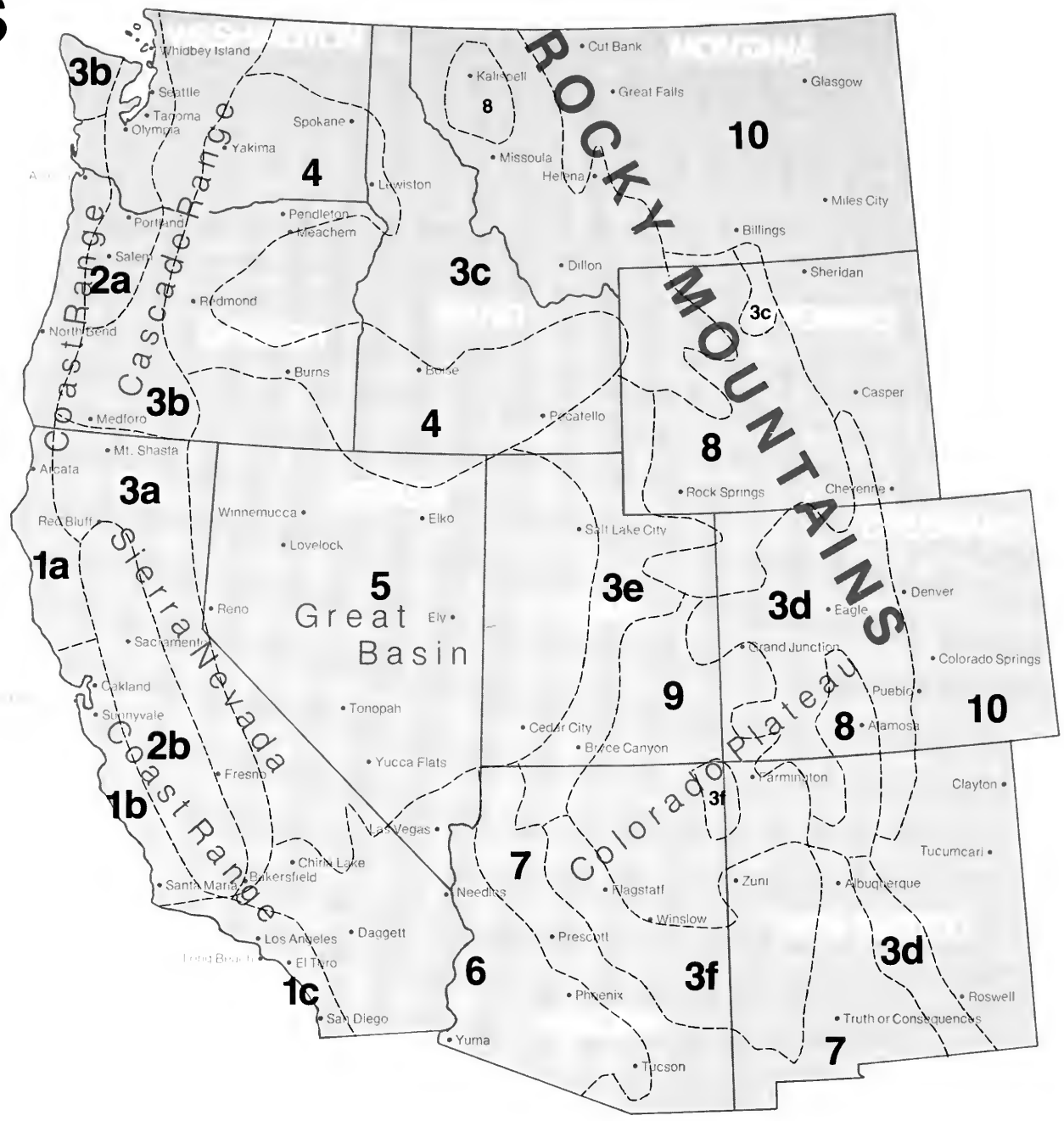
ZONE 6: Sonoran Desert

ZONE 7: Basin and Range

ZONE 8: High Mountain Valleys

ZONE 9: Colorado Plateau

ZONE 10: The Great Plains



MONTANA

ZONE 3c: High Mountains (Northern Rockies)

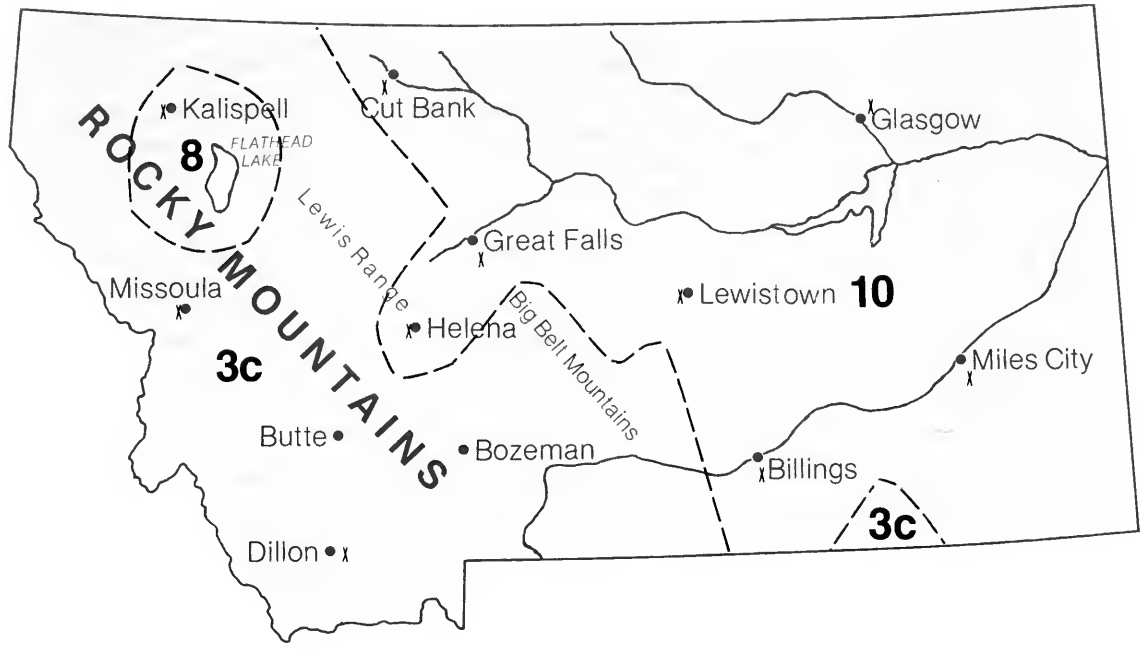
Missoula
Dillon

ZONE 8: High Mountain Valleys

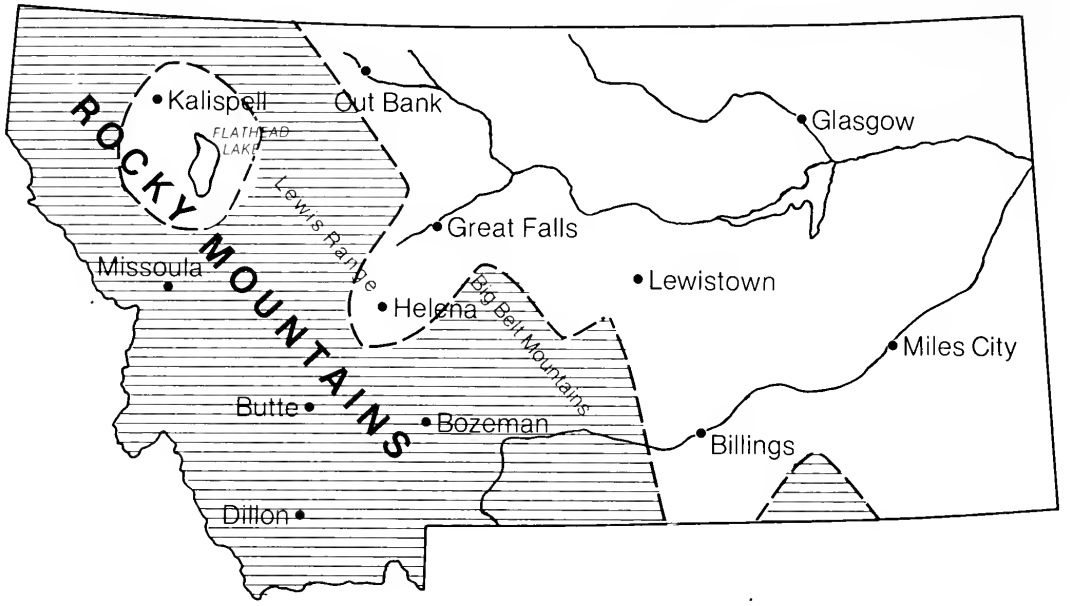
Kalispell

ZONE 10: Great Plains

Billings
Cut Bank
Glasgow
Great Falls
Helena
Lewistown
Miles City



ZONE 3c: High Mountains
(Northern Rockies)
Zone Summary



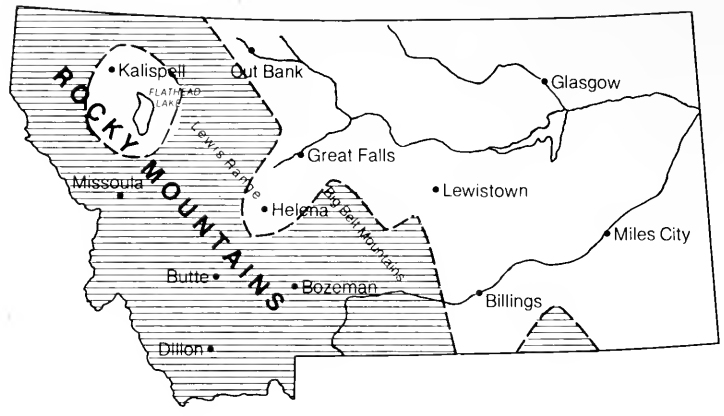
The topography of the Northern Rocky Mountains is in contrast to that of many of the other high mountain regions of the West. There are no dominant trends to the mountain ranges in this zone with the exception of the Bitterroots. Most of the crests are 6,000 to 9,000 feet above sea level, but are surmounted here and there by higher peaks. The valleys and basins that separate the mountain masses also lack a distinct pattern and vary from steep-sided river valleys like the canyon of the Snake to broader basins such as those in western Montana.

In general, the region is drier than mountain areas to the west for some of the moisture in the Pacific air masses has been left on the western slopes of the Cascades. However, there is enough left to form clouds that produce rain and snow sufficient to support luxuriant forests throughout the region.

Altitude and aspect of slopes are the dominant controls of cloudiness, precipitation, and temperature. The dominant air flow over the region is from the southwest to west in summer and west to northwest in winter. Slopes facing in these directions receive more wind, clouds and precipitation. In general, in the west and on northwest slopes, winter is the wettest part of the year. In the eastern part of the zone, there is a secondary spring maximum in May. September may also be wet. The leeward slopes of the mountains and the valley floors are sunnier and less precipitous than the western slopes.

Winters are cold although less so than the Great Plains to the east. Much of the air that passes across the region is modified marine air that originated over the Pacific Ocean. An outbreak of cold air from Canada will leave pools of cold air in the valleys for days. Severe blizzards may occur at this time. The summer season is short but long hours of daylight at these latitudes stimulate plant growth. Occasional hot spells send the temperatures up to one hundred degrees but average July temperatures in the valleys are in the high sixties.

ZONE 3c: High Mountains
(Northern Rockies)
MISSOULA, MONTANA
Station Summary



Missoula is situated in the heart of the Montana Rocky Mountains in the extreme north portion of the Bitterroot Valley, and about 5 miles east of the confluence of the Bitterroot and Clark Fork Rivers. The Clark Fork Valley begins at Missoula and extends about 20 miles west-northwestward. The Bitterroot Valley extends about 70 miles due southward from Missoula. The Continental Divide is 60 to 80 miles east of Missoula, and the Bitterroot Range is only about 20 miles away to the southwest. These two mountain ranges have a marked effect on the climate of Missoula.

The prevailing flow of air aloft over western Montana is from the west and southwest during spring and summer months, and from the west and northwest during the winter months. Since this air must pass over the Bitterroot Range, it loses much of its moisture on the western slopes of these mountains. As a result, Missoula receives only between 12 inches and 15 inches of precipitation annually on the average. This small amount of precipitation makes for a semi-arid climate. There is sufficient irrigation water, however, from the nearby mountains. The heaviest precipitation is received during May and June, with average rainfall of about 2 inches in each of these months.

Generally the spring months are cool and a little damp, with almost daily shower activity during May and June. The last spring freeze occurs about the middle of May normally, and there are about 137 growing days each year between the last spring freeze and the first fall freeze. The summer months are dry with moderate temperatures and cool nights. Seldom does the temperature reach 100°. Minimum temperatures during July and August average near 50°. Oppressively warm nighttime temperatures are unknown.

In the winter, the Continental Divide shields the Missoula area from much of the severely cold air which moves down the continent from arctic regions. Because of this shielding effect, many of the cold waves which sweep down over eastern Montana miss the Missoula area entirely. Under certain conditions, however, the cold arctic air does break over the Continental Divide, and moves with force into the Bitterroot and Clark Fork Valleys. When this happens, Missoula experiences severe blizzard conditions. The cold air is "funnelled" to the City through "Hell Gate" which is the mouth of the Clark Fork River canyon at Missoula. Locally these blizzards are referred to as "Hell Gate Blizzards." After the valleys of western Montana are filled with the cold air, prolonged cold spells may occur. January is the coldest month, although periods of subzero weather occur occasionally in December and February. Rarely, there are brief periods of subzero weather in November and March. During the winter months the sunshine is limited to about 30 percent of the possible amount.

ZONE 3c: High Mountains
(Northern Rockies)
MISSOULA, MONTANA
Station Data

Latitude: 46°55′N
Longitude: 114°05′W
Time Zone: Mountain
Elevation: 3190′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	3539	6516	11139	15686	20230	21937	26415	21346	15410	9221	4655	2033	13261
Direct Beam Normal Incidence *(KJ/M²-Day)*	10437	14756	19795	24833	30232	33831	36710	32751	27352	20514	12237	8998	22789
Total Horizontal Insolation *(BTU/FT²-Day)*	311.8	574.2	981.5	1382.2	1782.5	1933.0	2327.5	1880.9	1357.8	812.5	410.2	267.2	1168.5
Direct Beam Normal Incidence *(BTU/FT²-Day)*	921	1302	1746	2190	2667	2984	3238	2889	2413	1810	1079	794	2010
Total South Wall Insolation *(BTU/FT²-Day)*	430	662	853	815	770	719	865	987	1086		573	365	
Percent of Possible Sunshine	29	39	48	52	57	58	80	75	65	57	32	25	54
Mean Cloud Cover	8.5	8.2	7.9	7.6	6.9	6.5	3.6	4.3	5.5	6.8	8.3	8.7	6.9
Percent of Total Horizontal to Extraterrestrial Insolation	38.9	45.0	49.0	53.0	57.4	59.5	65.8	63.7	60.9	54.7	42.0	36.2	55.8

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	20.8	27.2	33.3	43.9	52.2	58.9	66.6	65.0	55.3	44.1	32.3	24.7	43.7
Average Daily Maximum	28.6	35.8	43.8	56.6	65.9	72.5	84.3	82.5	70.8	56.8	40.8	31.9	55.9
Average Daily Minimum	12.9	18.6	22.8	31.1	38.5	45.2	48.9	47.5	39.8	31.3	23.7	17.5	31.5
Winter/Summer Design	-6						88						

Total Heating Deg-Days for Month	1370	1058	983	633	397	201	39	71	301	648	981	1249	7931
Total Cooling Deg-Days for Month	0	0	0	0	0	18	89	71	10	0	0	0	188
Percent Relative Humidity *(Night)*	82	81	75	68	66	69	55	53	69	78	86	85	72
Wind Direction	ESE	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	E	NW
Wind Speed *(MPH)*	5.4	5.6	6.6	7.5	7.2	6.9	6.7	6.6	6.0	5.0	4.9	4.8	6.1

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

*(To find Total Solar Radiation on a Tilted Surface add the figure from **TABLE 3a.** to that of **TABLE 3b.**)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

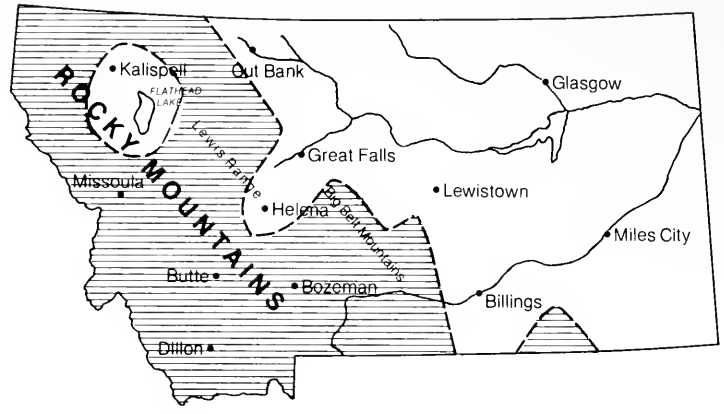
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	390	692	1117	1476	1838	1967	2407	2008	1540		517	333	
	30	448	771	1192	1491	1795	1893	2341	2018	1633		598	382	
	45	483	810	1201	1425	1654	1716	2136	1910	1630		647	411	
	60	492	803	1145	1283	1425	1448	1806	1691	1533		659	417	
	75	473	753	1026	1075	1123	1108	1372	1376	1347		634	402	
	90	430	662	853	815	770	719	865	987	1086	972	573	365	
45° ORIENT	15	365	653	1072	1438	1809	1942	2364	1958	1479		482	312	
	30	400	700	1107	1439	1752	1858	2261	1938	1521		531	341	
	45	415	710	1090	1356	1623	1702	2101	1828	1491		552	353	
	60	408	682	1016	1219	1425	1478	1820	1630	1379		543	347	
	75	380	623	899	1037	1178	1204	1490	1369	1209		506	324	
	90	374	533	737	817	899	904	1112	1059	979		443	285	
90° ORIENT	15	306	565	961	1349	1738	1886	2266	1833	1329		401	263	
	30	294	541	916	1273	1631	1766	2114	1724	1258		385	253	
	45	275	507	848	1165	1484	1599	1914	1570	1162		359	236	
	60	249	458	757	1028	1300	1395	1669	1380	1034		326	214	
	75	215	393	648	869	1089	1161	1389	1161	886		281	185	
	90	177	324	526	693	860	911	1039	921	716	465	232	152	

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	3	5	6	7	8	6	5		1	1	
	30	4	8	13	19	24	26	31	25	18		5	4	
	45	9	17	29	40	52	57	68	55	40		12	8	
	60	16	29	49	69	89	97	116	94	68		20	13	
	75	23	43	73	102	132	143	173	139	101		30	20	
	90	31	57	98	138	178	193	233	188	136	82	41	27	

ZONE 3c: High Mountains
(Northern Rockies)
DILLON, MONTANA
Station Summary



Situated in the Beaverhead River Valley of Beaverhead County, in an area of marked valley-mountain configurations, Dillon has in many respects a climate fairly typical of Northern Rocky intermountain valleys. Many of the features usually associated with interior higher plateaus are found here. Nearby mountains rise to nearly 10,000 feet above sea-level, while the valley floor (some 10 to 15 miles wide in this area) averages about a mile above sea-level. Most drainages in the area run generally northward. The effects of this mountain country on Dillon climate are quite pronounced, and combine to produce summers that are agreeably warm during the day but also pleasantly cool at night. Reference to the tables show the moderate range of summertime temperatures, as well as the almost complete lack of uncomfortably hot summer weather. High relative humidity is rarely a summer "comfort" problem. Usually the warmer afternoons carry relative humidity values somewhere in the 15 to 35 percent range—far below the humidity problem level.

Winter weather around Dillon is not as severely cold as commonly thought by residents of other areas. The cold waves that invade the north-central states several times each winter don't penetrate very often as far southwestward as Dillon, because of the protection afforded by the several mountain ranges to the northeast of this section of the Beaverhead Valley. However, when they do reach the Dillon area—as they do two or three times in an average year—below zero temperatures may occur, even though it is seldom that cold for more than two or three days at a time and then mostly during early morning hours. Minimums as cold as zero occur on the average only 22 days a year. The coldest observed in the 30-year period was only −36°. The few winter cold waves that do occur usually end with southwest "chinook" winds blowing "down" the Beaverhead Valley, occasionally producing temperature rises of 50° or more within a few hours. It must be noted, however, that Beaverhead "chinooks" are seldom accompanied by the very strong winds sometimes observed 100 miles or more to the northeast. Windstorms, in fact, are seldom a problem here.

In this land of clear nights and hardy crops, frosts and freezes don't have quite the same significance that they do in warmer parts of the nation, but the record of agriculture in the area shows that there is usually plenty of growing season to support a multi-million dollar livestock and crop industry. The average last in spring date of a 32° minimum is May 31, the first in fall September 7, giving an average freeze-free season of 96 days. Of much greater significance, however, is the 143-day average season between 28° occurrences (May 9 and September 29), providing plenty of time for maturing hays, grasses, grains, and other semi-hardy crops.

Precipitation during the 30-year period has averaged 11.41 inches at Western Montana College on the south side of the city. This would class the area as semi-arid, but as so often the case with classifying climates, this is an oversimplification. On the surrounding mountains substantial winter snowfall, and larger precipitation amounts during the rest of the year, produce ample water supplies for irrigation and other uses. It is quite important to note that, of the annual average of 11.41 inches, 8.43 inches (or 74 percent) fall during the April 1—September 30 growing season, and the wettest months by quite a margin are May and June; almost ideal for vegetation. Excessively heavy rains are not a problem here—in 30 years the greatest one-day total was only 1.79 inches in September 1940. For this elevation, snowfall is less than would be expected—only 38.8 inches a year, but snow is more plentiful on the nearby mountain slopes.

ZONE 3c: High Mountains
(Northern Rockies)
DILLON, MONTANA
Station Data

Latitude: 45°15′N
Longitude: 112°33′W
Time Zone: Mountain
Elevation: 1588′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	5975	9604	14518	18600	22575	24326	27147	22962	17263	11613	6832	5708	15544
Direct Beam Normal Incidence *(KJ/M²-Day)*	14036	18355	22674	26993	30232	33831	35990	32391	27352	22314	15836	12956	24520
Total Horizontal Insolation *(BTU/FT²-Day)*	526.5	846.2	1279.2	1638.9	1989.2	2143.5	2392.0	2023.3	1521.1	1023.3	602.0	450.1	1369.6
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1238	1619	2000	2381	2667	2984	3175	2857	2413	1968	1397	1143	2163
Total South Wall Insolation *(BTU/FT²-Day)*	903	1126	1174	950	806	733	829	1013	1199	1244	968	753	976
Percent of Possible Sunshine	43	52	58	60	60	61	78	74	65	58	43	40	58
Mean Cloud Cover	7.4	7.2	7.1	7.0	6.8	6.4	3.9	4.5	5.5	6.0	7.2	7.4	6.4
Percent of Total Horizontal to Extraterrestrial Insolation	48	52	55	57	58	60	65	64	61	58	50	47	58

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	20.2	25.5	29.6	41.1	50.4	57.5	66.4	64.6	54.7	45.0	31.8	23.9	42.6
Average Daily Maximum	34	38	45	56	65	74	83	81	71	61	47	37	58
Average Daily Minimum	12	15	22	30	37	43	48	45	37	31	22	15	30
Winter/Summer Design	-10						87						

Total Heating Deg-Days for Month	1389	1106	1097	717	453	238	54	85	325	620	996	1274	8354
Total Cooling Deg-Days for Month	0	0	0	0	0	13	97	73	16	0	0	0	199
Percent Relative Humidity *(Night)*													
Wind Direction													
Wind Speed *(MPH)*													

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

*(To find Total Solar Radiation on a Tilted Surface add the figure from **TABLE 3a.** to that of **TABLE 3b.**)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

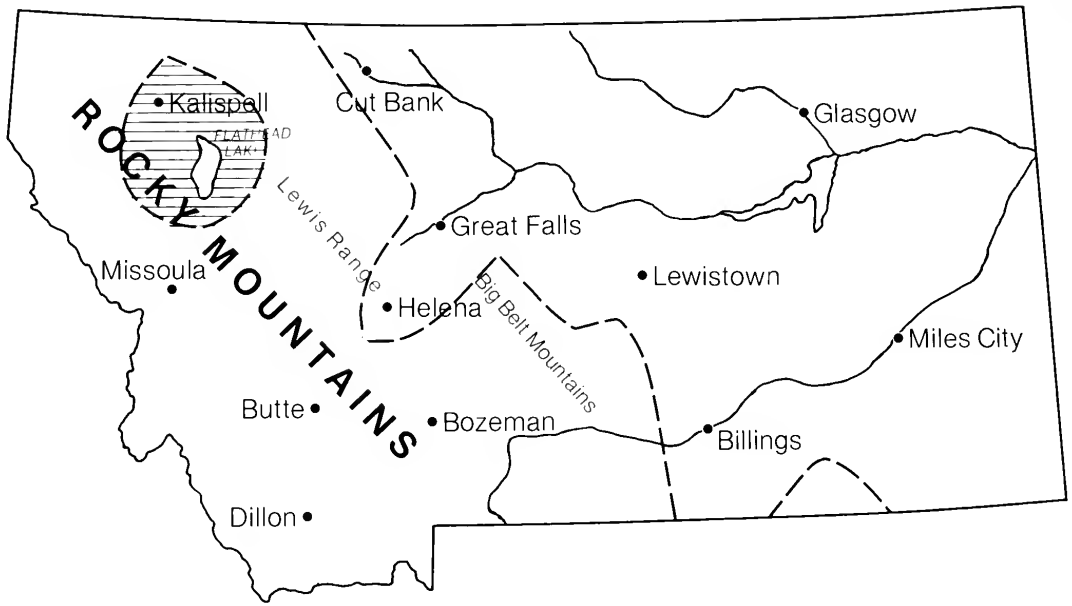
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	715	1074	1491	1762	2054	2180	2462	2157	1730	1273	803	607	1526
	30	864	1279	1616	1786	2001	2092	2384	2162	1836	1448	959	731	1593
	45	963	1330	1645	1709	1836	1886	2162	2038	1832	1535	1058	813	1567
	60	1003	1341	1578	1534	1568	1576	1812	1792	1718	1528	1093	846	1449
	75	983	1271	1417	1276	1217	1183	1357	1443	1502	1429	1063	829	1247
	90	903	1126	1174	950	806	733	829	1013	1199	1244	968	763	976
45° ORIENT	15	655	1001	1421	1713	2021	2152	2422	2103	1660	1192	740	558	1470
	30	749	1102	1484	1707	1954	2055	2328	2076	1708	1295	836	635	1494
	45	799	1139	1475	1620	1804	1873	2134	1952	1674	1326	885	677	1447
	60	803	1110	1381	1455	1578	1618	1849	1733	1545	1277	881	680	1326
	75	761	1024	1226	1232	1293	1308	1494	1445	1349	1166	828	645	1148
	90	676	881	1004	964	977	971	1104	1108	1086	988	730	574	922
90° ORIENT	15	514	832	1249	1598	1940	2089	2328	1969	1487	1003	589	442	1337
	30	495	798	1189	1505	1817	1952	2169	1848	1404	958	565	426	1260
	45	463	750	1100	1373	1649	1761	1959	1678	1293	894	529	399	1154
	60	426	681	982	1209	1441	1531	1703	1470	1150	806	484	366	1021
	75	368	588	842	1019	1202	1270	1413	1232	982	694	417	317	862
	90	307	488	684	811	946	992	1103	973	792	571	347	264	690

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	2	3	4	6	7	7	8	7	5	3	2	2	5
	30	7	11	17	22	27	29	32	27	20	14	8	6	18
	45	15	25	37	48	58	63	70	59	45	30	18	13	40
	60	26	42	64	82	99	107	120	101	76	51	30	22	68
	75	39	63	95	121	147	159	177	150	113	76	45	33	102
	90	53	85	128	164	199	214	239	202	152	102	60	45	137

ZONE 8: High Mountain Valleys
Zone Summary



Within the Rocky Mountain system there are a series of relatively large flat valleys extending in a north-south direction behind the Front Ranges. These include the San Luis Valley of southern Colorado, the "parks" of central and northern Colorado, and the Wyoming Basin. These lie at elevations that range from 7,500 to 10,000 feet and take on characteristics of the mountain zone in which they are located. However, there are significant differences.

As is true of most of the West, precipitation occurs when cyclonic storms pass over the area. The air that is forced to rise in crossing the mountains drops some of its moisture on the valleys below. However, smaller quantities are recorded there than on the windward slopes or even than on some of the leeward slopes. Summer thunderstorms, generated when air rises up mountain slopes heated by the intense polar radiation received at high elevations, drift over the valleys in late afternoon and evening providing sustenance to the pastures and crops below.

Maximum quantities of precipitation fall from the thunderstorms of late spring and summer. The light snowfalls of winter do not have a very high water content and occur less frequently than the spring and summer rains. Total annual rainfall totals are low varying from five to fifteen inches, and droughts may occur when either the winter or summer wet periods do not occur.

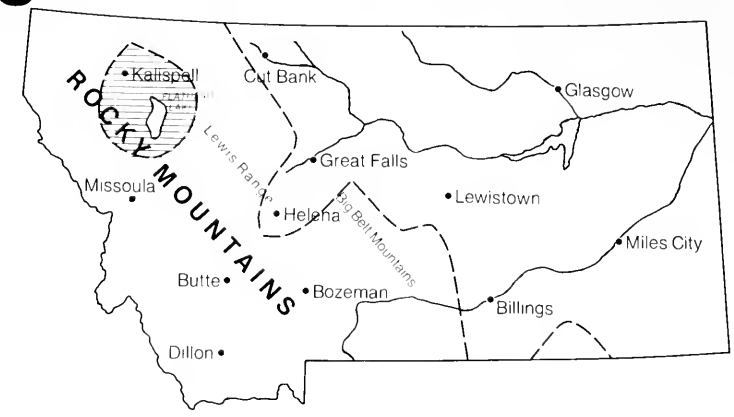
Although the dominant flow of air is from west to east, occasional outbreaks of polar air penetrate the region and send winter temperatures far below zero. Even with a westerly flow prevailing winter temperatures may fall below zero at night and get barely above freezing in the day. Large amounts of sunshine during the day send temperatures into the high seventies and low eighties. Occasional heat waves cause even higher temperatures to occur.

These areas are blessed with large quantities of solar radiation, particularly on the dry clear days of fall and winter.

ZONE 8: High Mountain Valleys

KALISPELL, MONTANA

Station Summary



Since the climate of the Flathead Valley differs materially from that just east of the Continental Divide (the Divide is approximately 40 miles to the east of the station), it can principally be attributed to the influence of the topographical features. The high mountains to the east form an effective barrier to many severe winter cold waves that move down over sections east of the Rockies from Alberta. The mountains to the east rise abruptly 4,500 feet above the valley floor. Their elevation and snow remaining on the crests until late spring assure frequent and beneficial rains by cooling of moist air moving from the west.

In addition to Flathead Lake, the valley contains four smaller lakes, three rivers, and numerous streams and sloughs. Until late in the winter when a large portion of the lakes and sloughs become frozen over, this water surface tends to limit temperature extremes. This effect is most noticeable in the southern end of the valley, because of more influence of Flathead Lake. Due to its size, Flathead Lake seldom freezes over.

The weather at the airport is considerably different in some respects from the weather in Kalispell. Generally there is more cloudiness at the airport since it is closer to the mountains to the east and north. Moist air moving in from the west and southwest, lifting and cooling as it moves over the mountains, is the major cause. In connection with this, there is, on the average, more precipitation on the east side of the valley than on the west side. Average snowfall during the winter at the airport is 68 inches and in Kalispell it is 49 inches.

Starting in March and lasting through September, the prevailing wind from 11:00 a.m. until 7:00 p.m. is from the southeast. This wind blows off Flathead Lake and is caused by the land surfaces heating more in the daytime than the water surface of the lake. This wind is very noticeable both at Kalispell and the airport, often reaching 20 m.p.h. and occasionally quite gusty. There are, of course, times when the wind during this period is not from the southeast. Other effects such as cloudiness, frontal passages, etc., may cause the wind to be from another direction. The year around prevailing wind direction at Kalispell is from the west, at the airport it is from the south. Wind speeds average considerably stronger at the airport than in Kalispell.

In the winter, when a cold wave moving down the east side of the Continental Divide does come through the mountains, the airport is in direct line of the pass the cold air comes through. During these cold waves the wind is from the northeast and will usually have speeds reaching 30 to 40 m.p.h. The strongest gust reported during one of these storms was 84 m.p.h. As the cold air moves down the valley it spreads out, decreasing the wind velocity, and mixes with the warmer air of the valley. Unless these cold strong winds persist for 3 or 4 days, the wind in the lower part of the valley will be from the northwest, because of the influence of Flathead Lake and the mountains to the west. This wind is always much stronger in the northeast end of the valley where the airport is located than any other place in the valley. In the northwest corner where Whitefish is located, and in the southeast part of the valley, there is rarely much wind from this storm.

ZONE 8: High Mountain Valleys

KALISPELL, MONTANA

Station Data

Latitude: 48°18′N
Longitude: 114°16′W
Time Zone: Mountain
Elevation: 2965′

TABLE 1: Daily Solar Data (*mean*)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	3960	6840	12240	17640	22680	25200	25920	21960	16200	9720	4680	2880	14160
Direct Beam Normal Incidence *(KJ/M²-Day)*	9360	14040	20160	25200	30960	34200	36720	32400	27360	19800	11520	7560	22440
Total Horizontal Insolation *(BTU/FT²-Day)*	348	620	1077	1552	1996	2218	2281	1933	1426	855	412	253	1248
Direct Beam Normal Incidence *(BTU/FT²-Day)*	824	1236	1774	2218	2725	3010	3232	2851	2408	1742	1014	665	1975
Total South Wall Insolation *(BTU/FT²-Day)*	577	806	1025	969	879	814	892	1057	1220	1091	640	374	862
Percent of Possible Sunshine	19	29	54	47	44	68	74	61	50	63	31	22	47
Mean Cloud Cover	9.1	9.1	7.8	8.4	8.4	5.5	4.5	7.2	7.4	5.5	8.2	8.8	7.4
Percent of Total Horizontal to Extraterrestrial Insolation	37	44	50	54	58	60	65	63	61	53	41	33	56

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	20	26	35	44	49	60	65	62	54	43	26	14	41
Average Daily Maximum	26	33	45	55	59	74	80	76	66	59	34	24	53
Average Daily Minimum	13	18	24	33	39	45	49	47	42	26	18	4	30
Winter/Summer Design	-24						86						

Total Heating Deg-Days for Month	1423	1120	1070	690	437	249	72	126	360	698	1029	1280	8554
Total Cooling Deg-Days for Month	0	0	0	0	0	9	51	48	0	0	0	0	117
Percent Relative Humidity *(Night)*	78	78	74	68	67	71	68	67	74	78	79	80	73
Wind Direction													
Wind Speed *(MPH)*	7	6	8	8	8	8	7	7	7	6	6	6	7

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

(To find Total Solar Radiation on a Tilted Surface add the figure from ***TABLE 3a.*** *to that of* ***TABLE 3b.****)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

TABLE 3a: Direct Beam+Diffuse

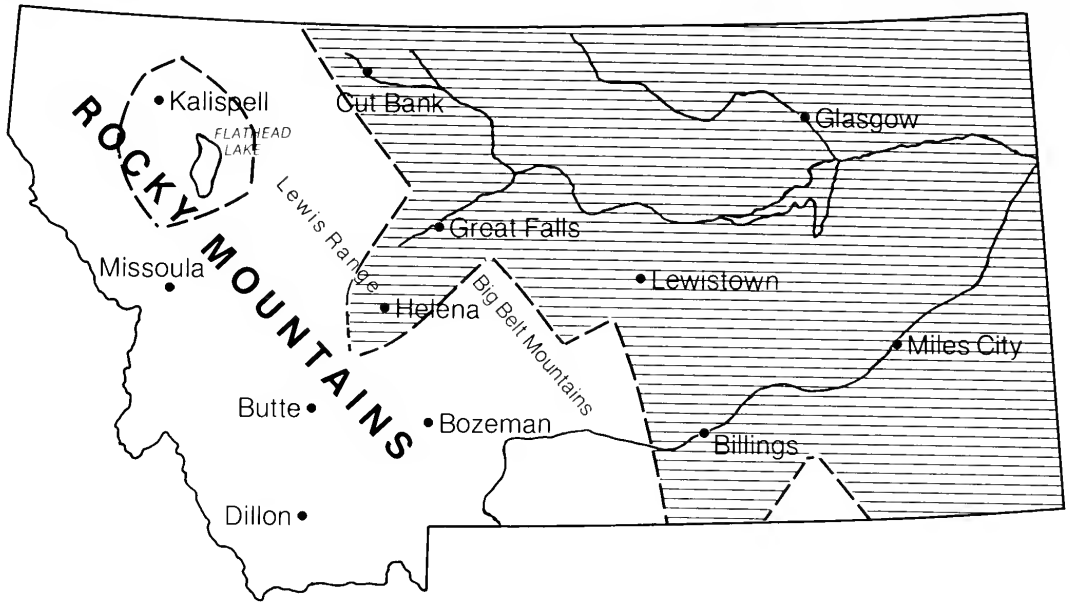
	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	464	775	1257	1684	2080	2276	2367	2081	1645	1072	537	323	1380
	30	555	886	1366	1722	2046	2202	2311	2105	1767	1227	635	377	1433
	45	615	946	1396	1662	1895	2002	2119	2004	1782	1309	697	410	1403
	60	639	953	1347	1509	1637	1688	1803	1784	1691	1313	719	421	1292
	75	626	905	1220	1272	1291	1283	1385	1461	1499	1239	700	409	1107
	90	577	806	1025	969	879	814	892	1057	1220	1091	640	374	862
45° ORIENT	15	428	725	1198	1634	2040	2242	2322	2025	1573	1002	497	301	1332
	30	484	793	1255	1640	1987	2154	2248	2014	1634	1096	557	334	1350
	45	515	817	1251	1568	1849	1980	2078	1910	1616	1128	587	349	1304
	60	517	795	1178	1420	1630	1723	1817	1711	1506	1095	585	347	1194
	75	491	735	1053	1215	1351	1406	1490	1445	1330	1008	551	327	1033
	90	439	636	870	962	1031	1053	1119	1124	1084	864	488	290	830
90° ORIENT	15	343	610	1054	1515	1945	2162	2221	1883	1395	840	403	250	1218
	30	332	586	1006	1430	1824	2022	2075	1773	1324	805	388	241	1151
	45	313	552	935	1310	1661	1831	1882	1618	1227	757	364	226	1056
	60	286	503	839	1161	1458	1600	1645	1427	1096	687	333	206	937
	75	249	434	722	985	1223	1334	1374	1204	943	594	288	178	794
	90	208	361	590	789	967	1049	1080	959	766	493	240	148	637

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	4	5	7	8	8	7	5	3	1	1	4
	30	5	8	14	21	27	30	31	26	19	11	6	3	17
	45	10	18	32	45	58	65	67	57	42	25	12	7	37
	60	17	31	54	78	100	111	114	97	71	43	21	13	62
	75	26	46	80	115	148	164	169	143	106	63	31	19	92
	90	35	62	108	155	200	222	228	193	143	85	41	25	125

ZONE 10: The Great Plains

Zone Summary



Extending from the Canadian Arctic into Mexico through the states of Montana, Wyoming, Colorado, New Mexico and Texas, is the Great Plains. The climate of an area with such a large latitudinal spread will obviously vary, but the region does share a certain number of climatic characteristics. The region is semi-arid, hot in summer, cold in winter, windy, and receives most of its precipitation in late spring and summer from air masses that move northward from Mexico.

The landscape is essentially rolling hill country. In its natural condition, the land supported a short-grass steppe type of vegetation. Today, wheat fields, irrigated pastures and other crops have replaced the native vegetation.

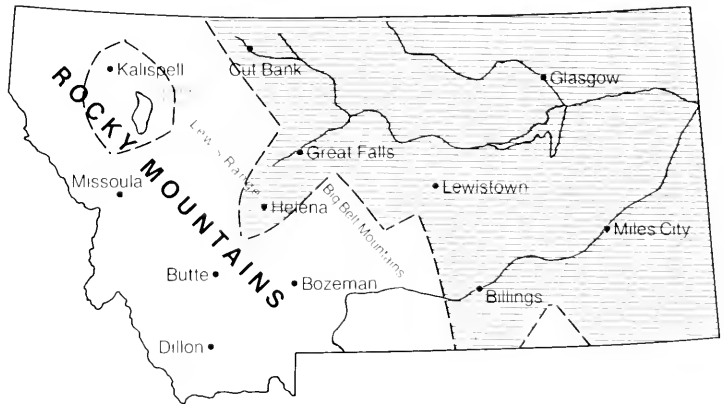
In the winter, polar air masses which surge out of Canada with monotonous regularity are interspersed by periods of cyclonic storms, which send raging blizzards across the region. In other instances, along the northern section of the province, *Chinook* winds bring clear, dry, warm weather conditions in the middle of a cold winter.

Precipitation values are low throughout the region, generally between 10 and 15 inches. Winter storms usually drop small quantities of snow across the region, but an occasional storm that sucks warm moist air into its system may paralyze large areas with heavy snow. Late spring and summer rains which provide most of the moisture for the rangelands are highly variable; the region has suffered through many drought periods.

Winters are usually cold with certain exceptions noted earlier. Chinook winds which result from the compressional heating of air that has crossed the Continental Divide and descended to the Great Plains bring relief to the northern part of the Great Plains. In the south occasional invasions of air from the Gulf of Mexico bring surcease from cold winter temperatures.

Summers are uniformly hot over the whole region. Long days coupled with high insolation values and air with a tropical origin result in maximum diurnal temperatures over 100°F. The higher humidities of this region result in warm nights at this time of the year.

ZONE 10: The Great Plains
BILLINGS, MONTANA
Station Summary



Billings, Montana, at an elevation of 3,100-3,600 feet above mean sea level, is situated in the borderline area between the Great Plains and the Rocky Mountains and has a climate which takes on some of the characteristics of both regions. Its climate may be classified as semi-arid, but with irrigation and the favorable distribution of the precipitation during the spring and fall months, it is possible to raise a variety of crops in the area.

The average annual precipitation for the immediate area is a little more than 14 inches with about a third of this amount falling during May and June. June is the wettest month, followed in order by May, April, September, and October. The period of least precipitation is from November through February. These four months normally produce less than 20 percent of the year's precipitation; even so, heavy snows of from 6 inches to 1 foot are not uncommon during these winter months, particularly during November and December. The heaviest snows, however, occur during the spring and fall months when the temperature and moisture conditions are most favorable. Snow seldom accumulates to great depths on the ground because of the occurrence of thawing periods, even during mid-winter. Thunderstorms, which occur on slightly over 30 days out of the year, are restricted mainly to the warm season, May through September. These storms are frequently accompanied by strong, gusty winds and occasionally by hail. Destructive hailstorms, however, are rather infrequent. The most recent one occurred on July 2, 1958. Upslope fog and low clouds are common with east and northeast winds during the colder two-thirds of the year with an occasional occurrence of these conditions during the warmest months. Radiation fogs seldom occur and are usually of short duration.

Winter is usually cold, though not extremely so, and generally affords mild periods of a week to several weeks in length. The winter cold periods are ushered in by moderately strong north to northeast winds and snow, with the coldest period coming the first or second night after the snow ends and the sky clears. True blizzard conditions are not observed very often in town, but in the surrounding rural areas this condition may develop several times during an average winter. The cold waves "break" abruptly with the onset of moderate to strong west to southwest winds, attended by variable or increasing cloudiness. This wind is sometimes a Foehn condition (Chinook), but is more often a drainage wind moving down the Yellowstone Valley which transports warmer air of Pacific origin to the area. Occasionally an "open winter" is experienced; this happens when many of the severe cold waves pass far to the east. A recent example of a "mild winter" was the winter of 1969-1970 when only two days of below-zero temperatures were observed with the coldest −7° on January 17.

The spring brings a period of frequent and rapid fluctuations in the weather. It is usually cloudy and cool with frequent periods of rain and/or snow. A snowstorm in April of 1955 left over 42 inches of snow in a four-day period. As the season progresses, snows become less frequent until late May and June when rain is the rule. The last freezing temperatures in spring usually occur in the valley before May 15, though they have occurred as late as June 23.

The summer season is characterized by warm days with much sunshine and low humidities, but the nights are cool because of the altitude and the air drainage from the higher terrain nearby. Seldom is there a protracted rainy spell during this season. However, frequent thunderstorms bring threatening afternoon cloudiness, but usually only small amounts of rain.

The first freezing temperatures of the fall season occur around September 25 in the valley, but they have been noted as early as August 25. Over the years, the fall months have been about evenly distributed between cold, wet ones and mild, dry, pleasant ones. The change to severe winter weather does not as a rule arrive before the middle of November, but there have been years when the more severe type of winter weather has been delayed until late in December. The snows which occur during the early fall months seldom accumulate and stay on the ground for any appreciable period.

ZONE 10: The Great Plains
BILLINGS, MONTANA
Station Data

Latitude: 45°48′N
Longitude: 108°32′W
Time Zone: Mountain
Elevation: 3567′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	5516	8661	13499	17322	21708	24669	27053	22952	16683	11199	6371	4780	15034
Direct Beam Normal Incidence *(KJ/M²-Day)*	14756	18355	22314	26633	31311	34550	35630	33111	27712	22674	16555	13676	24840
Total Horizontal Insolation *(BTU/FT²-Day)*	486.0	763.2	1189.5	1526.3	1912.8	2173.7	2383.7	2022.4	1470.0	986.8	561.4	421.2	1324.7
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1302	1619	1968	2349	2762	3048	3143	2921	2444	2000	1460	1206	2191
Total South Wall Insolation *(BTU/FT²-Day)*	825	981	1079	888	794	751	844	1029	1166	1208	893	713	931
Percent of Possible Sunshine	48	54	61	59	61	64	78	77	68	62	46	45	62
Mean Cloud Cover	7.2	7.1	7.2	7.1	6.5	5.9	4.0	4.1	5.3	5.6	6.8	6.8	6.1
Percent of Total Horizontal to Extraterrestrial Insolation	49.3	52.5	54.2	56.0	59.2	61.4	64.5	64.0	61.4	58.9	52.0	49.3	58.8

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	21.9	27.4	32.6	44.6	54.5	52.6	71.8	70.1	58.9	49.3	35.7	26.8	46.3
Average Daily Maximum	31.2	37.1	42.1	55.8	65.7	73.7	85.6	83.8	71.3	61.0	45.0	35.8	57.3
Average Daily Minimum	12.5	17.7	23.1	33.4	43.3	57.5	58.0	56.3	46.5	37.5	26.4	17.7	35.3
Winter/Summer Design	-10						91						

Total Heating Deg-Days for Month	1336	1053	1004	612	333	131	10	15	221	487	879	1184	7265
Total Cooling Deg-Days for Month	0	0	0	0	8	59	220	173	38	0	0	0	498
Percent Relative Humidity *(Night)*	63	63	62	60	60	60	48	45	57	55	62	63	58
Wind Direction	SW	SW	SW	SW	NE	SW	SW	SW	SW	SW	SW	WSW	SW
Wind Speed *(MPH)*	13.1	12.5	11.7	11.8	11.1	10.5	9.8	9.7	10.5	11.2	12.2	13.0	11.4

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

*(To find Total Solar Radiation on a Tilted Surface add the figure from **TABLE 3a.** to that of **TABLE 3b.**)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

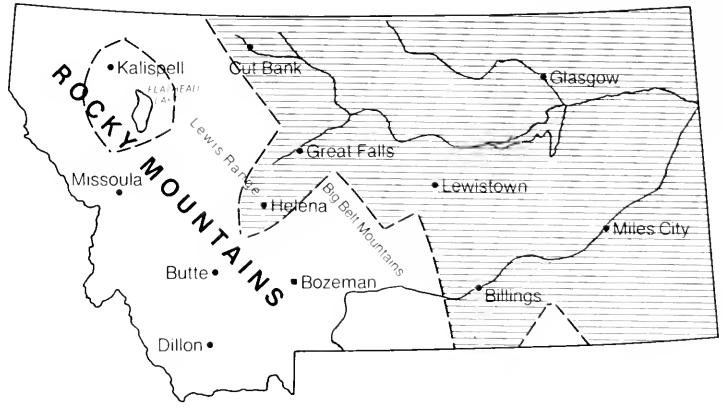
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	657	956	1379	1635	1975	2215	2458	2161	1671	1229	745	567	1471
	30	792	1093	1488	1654	1926	2129	2284	2170	1773	1398	887	683	1531
	45	880	1167	1512	1581	1769	1922	2166	2050	1770	1483	977	758	1503
	60	916	1173	1448	1421	1516	1608	1820	1807	1662	1479	1009	790	1387
	75	898	1109	1300	1185	1183	1208	1369	1459	1456	1385	980	774	1192
	90	825	981	1079	888	794	751	844	1029	1166	1208	893	713	931
45° ORIENT	15	603	894	1316	1591	1943	2135	2416	2106	1604	1150	686	521	1418
	30	687	977	1371	1583	1880	2088	2326	2082	1650	1251	774	593	1439
	45	732	1006	1360	1502	1738	1907	2136	1961	1618	1281	818	632	1391
	60	795	977	1272	1348	1522	1649	1854	1744	1494	1236	814	635	1273
	75	697	900	1129	1144	1251	1334	1501	1458	1306	1130	766	603	1102
	90	620	773	926	897	948	991	1112	1121	1054	959	675	538	885
90° ORIENT	15	476	751	1163	1489	1866	2118	2320	1968	1438	968	549	414	1293
	30	458	720	1107	1403	1743	1979	2162	1848	1359	925	527	399	1220
	45	430	676	1025	1281	1589	1786	1954	1680	1253	864	493	375	1117
	60	394	613	915	1129	1389	1554	1700	1473	1114	780	451	343	988
	75	342	529	785	953	1161	1290	1412	1236	953	672	389	298	835
	90	285	438	637	759	914	1009	1104	977	769	554	323	248	668

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	2	3	4	5	7	7	8	7	5	3	2	1	5
	30	7	10	16	20	26	29	32	27	20	13	8	6	18
	45	14	22	35	45	56	64	70	59	43	29	16	12	39
	60	24	38	59	76	96	109	119	101	73	49	28	21	66
	75	36	57	88	113	142	161	177	150	109	73	42	31	98
	90	49	76	119	153	191	217	238	202	147	99	56	42	132

ZONE 10: The Great Plains
CUT BANK, MONTANA
Station Summary



Located in foothill country on the eastern slopes of the Continental Divide, Cut Bank lies some 50 miles east to northeast of the summit of the Divide at the nearest point. In this area the Rocky Mountains end rather abruptly a few miles east of the summit, and the foothills, although rugged and in places rocky, are not as high above the plain as in other areas both to the north and to the south. The nearest hills of importance to Cut Bank's climate characteristics, outside of the Rockies themselves, are buttes and ridges rising to elevations near 5,000 feet about 20 miles to the northwest, and the Sweetgrass hills about 40-50 miles northeast, rising to elevations of nearly 7,000 feet. Cut Bank Creek flows through a deep channel running almost due south about one-half mile west of the city. Cut Bank, Two Medicine, and Birch Creeks join about 10 miles southeast of Cut Bank to form the Marias River. Cut Bank's unique location in a broad plain at least 20 miles from the nearest hills of important size has a marked influence on the character of the climate.

Small differences sometimes are noted in day-to-day weather in and around Cut Bank due to the local terrain—hills and valleys. The Cut Bank Airport, where the weather records have been made since December 1942, actually lies about 100 feet higher than most of the city, but differences between Airport and city are usually quite small—except that the Airport experiences more wind than the city. Cut Bank lies well within the so-called "Chinook Belt" of the Northern Rockies, and largely because of these Chinook (Foehn) winds, which occur several times for several days at a time each winter, its climate must be classified as modified continental. Winter cold air invasions from the north, characteristic of the continental climates in North America, while they do occur several times each season in the Cut Bank area, seldom last more than a few days without a "chinook" interruption. This particular feature of Cut Bank's climate is common to much of the surrounding area north to the Canadian Border and southeast to the Belt and Judith Mountains.

Cut Bank area precipitation averages about 11.5 to 12.0 inches a year, but the usual month-to-month distribution is most favorable for agriculture. Of the 11.58-inch average annual total 1941-70, 81 percent (9.36 inches) fell during the April-September growing season, and a little more than half fell during the May-July 3-month period most important to the growth of grains and grasses. Winter precipitation generally is light (less than ½ inch per month November-March, incl.), and almost invariably it falls as snow. Average yearly snowfall is about 36 inches, and seldom does snow depth exceed a few inches.

Summer weather in the Cut Bank area is rarely hot, and only on six days a year during the 1941-1970 period did the temperature rise to 90° or warmer. The warmest during 57 years of record was 107° on August 5, 1961. Coldest observed during the same period was −47° on February 15, 1936. Summertime afternoon temperatures average in the 70's or low 80's, and morning lows run in the 40's and 50's. Winters are cold much of the time, but the modifying influence of the "chinook" winds, so often observed during winter months, gives the area several spells of mild weather from November through March. During January, the coldest month, for example, 15 days on the average actually have experienced above-freezing temperatures sometime during the day. While snow can fall as late as June and as early as September, such occurrences are infrequent, and the snow season generally runs from late October to April. Heavy snowstorms are also infrequent, but more than 10 inches in a day have been observed a few times. Excessive rainfall is unusual, the greatest measured for any day in 45 years being 3.32 inches on June 12-13, 1937.

Severe storms in this area, outside of the occasional very strong "Chinook" cold season winds and the characteristic Arctic source cold wave, are not frequent. The most troublesome is the occasional summer season hailstorm that comes during the grain ripening season mid-to-late July. Hail is not widespread when it occurs, in most years hail has been reported somewhere in Glacier County during the growing season. An Air Force study of a 12-year sample of Cut bank Airport wind showed that wind speeds greater than 20 m.p.h. occur about 25 percent of the time.

ZONE 10: The Great Plains
CUT BANK, MONTANA
Station Data

Latitude: 48°36′N
Longitude: 112°22′W
Time Zone: Mountain
Elevation: 1170′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	4564	7806	12802	16851	21365	23212	25954	21524	15342	9888	5451	3795	14046
Direct Beam Normal Incidence *(KJ/M²-Day)*	12956	16915	21594	25913	30592	34191	36170	32751	26993	20874	14396	11877	23869
Total Horizontal Insolation *(BTU/FT²-Day)*	402.2	687.8	1128.0	1484.8	1882.6	2045.3	2286.9	1896.6	1351.8	871.3	480.3	334.4	1237.6
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1143	1492	1905	2286	2698	3016	3238	2889	2381	1841	1270	1048	2105
Total South Wall Insolation *(BTU/FT²-Day)*	760	972	1111	926	841	778	903	1045	1143	1142	850	616	924
Percent of Possible Sunshine	44	50	56	56	59	60	77	73	64	55	43	42	57
Mean Cloud Cover	7.3	7.4	7.3	7.4	6.9	6.5	4.0	4.6	5.7	6.3	7.2	7.3	6.5
Percent of Total Horizontal to Extraterrestrial Insolation	46.9	49.9	53.2	54.1	57.3	59.4	64.3	63.2	60.2	56.2	48.6	4.5	57.4

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	16.2	22.4	26.8	39.5	49.6	56.5	64.4	62.6	53.2	44.1	29.7	21.4	40.4
Average Daily Maximum													
Average Daily Minimum													
Winter/Summer Design	-20						85						

Total Heating Deg-Days for Month	1573	1193	1184	765	477	267	82	125	368	648	1059	1352	9033
Total Cooling Deg-Days for Month	0	0	0	0	0	12	64	50	14	0	0	0	140
Percent Relative Humidity *(Night)*													
Wind Direction													
Wind Speed *(MPH)*													

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

(To find Total Solar Radiation on a Tilted Surface add the figure from ***TABLE 3a.*** *to that of* ***TABLE 3b.****)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

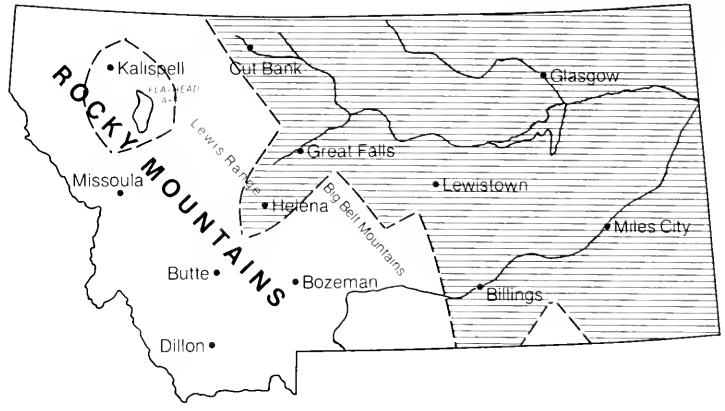
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	564	884	1330	1607	1957	2094	2375	2042	1552	1102	658	463	1386
	30	694	1029	1456	1641	1923	2024	2322	2065	1660	1268	801	565	1454
	45	782	1114	1496	1582	1782	1843	2131	1967	1671	1359	896	626	1438
	60	824	1133	1449	1436	1543	1561	1816	1753	1584	1367	937	668	1339
	75	817	1084	1318	1212	1227	1198	1396	1438	1404	1294	921	662	1164
	90	760	972	1111	926	841	778	903	1045	1143	1142	850	616	924
45° ORIENT	15	514	822	1264	1561	1921	2064	2330	1987	1486	1028	602	423	1333
	30	596	912	1332	1564	1870	1982	2258	1977	1539	1129	692	488	1362
	45	645	950	1334	1495	1740	1823	2089	1875	1520	1167	742	526	1325
	60	656	933	1260	1353	1535	1589	1828	1681	1415	1136	748	535	1222
	75	630	869	1130	1159	1274	1301	1500	1421	1249	1048	713	513	1067
	90	568	756	937	918	976	980	1129	1107	1017	901	638	463	866
90° ORIENT	15	397	677	1104	1450	1836	1995	2227	1848	1323	856	470	330	1209
	30	386	651	1054	1369	1723	1869	2081	1741	1256	821	455	321	1144
	45	366	616	982	1255	1570	1694	1888	1590	1164	773	429	304	1053
	60	337	564	883	1112	1378	1482	1651	1403	1040	703	395	280	936
	75	296	489	761	944	1157	1237	1380	1185	894	609	344	245	795
	90	247	409	623	756	916	974	1086	944	727	506	289	206	640

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	4	5	6	7	8	6	5	3	2	1	4
	30	5	9	15	20	25	27	31	25	18	12	6	4	17
	45	12	20	33	43	55	60	67	56	40	26	14	10	36
	60	20	34	56	74	94	102	114	95	68	44	24	17	62
	75	30	51	84	110	140	152	170	141	100	65	36	25	92
	90	40	69	113	148	188	204	229	190	135	87	48	33	124

ZONE 10: The Great Plains
GLASGOW, MONTANA
Station Summary



Founded in the days of national expansion as a railroad shop town, Glasgow is situated in the valley of the Milk River, about 20 miles upstream from where the Milk River joins the Missouri. It lies on the natural route from the plains to Marias Pass in the northern Rockies. The City is located on the valley floor at an average elevation of about 2,100 feet above sea level. Hills rise sharply from the northern edge of the City to flat "tableland" about 200 feet higher than the valley. The Weather Service Office is located on this flat land about 1 mile north-northeast of the City. A gradual incline commences 3 to 4 miles to the south and southwest of the City and reaches to the rolling hills which separate the Mile River drainage from the Fort Peck Reservoir on the Missouri. The northern shore of Fort Peck Reservoir lies about 15 miles south of Glasgow. This is a body of water impounded by Fort Peck Dam which was completed in 1939. The dam, at full capacity, backs water up the Missouri Valley for over 180 miles. The reservoir's shape is very irregular, but its average width south of Glasgow is about 10 miles.

Glasgow's climate is of the "continental" type, with a large annual range in temperature and limited precipitation. Fort Peck Reservoir, to the south, seems to have little climatic effect as far north as Glasgow, except for brief periods of morning fog in the late fall which occasionally drifts northward from the lake before "freeze-up."

While the normal annual precipitation for Glasgow is only 10.87 inches, 78 percent of it falls during the six so-called "growing months," April through September, with May and June accounting for 38 percent of the annual total. This average time distribution of precipitation helps to make the climate quite favorable for the growing of small grains. Winter precipitation nearly always falls as snow; but as a rule, although snow seldom accumulates to any great depth, it usually is formed into drifts in the open, unprotected areas. Blizzards during the winter months occur occasionally, but usually are of short duration; however, it is wise for travelers and stockmen to be on the alert for this danger during the winter months. Glasgow itself is well protected from most strong winds and blizzard conditions by hills to the north of the City, but occasionally the unprotected surrounding areas feel the full brunt of these winter storms.

Glasgow has a wide range of temperature. Winters are quite cold, with an average normal temperature of 13.8 degrees for the December-February period. The coldest temperature ever recorded was −59 degrees, which occurred in February 1936. Mild winter weather occasionally does occur, sometimes caused when the "chinook" or "foehn" wind, which descends the eastern slopes of the Rocky Mountains, reaches as far east as Glasgow. Very cold spells also occur, at least once each winter, but as a rule, these last only a few days. Summers are characterized by warm, sunny weather which can last for several weeks at a time. The average normal temperature for the summer, June through August, is 67.2 degrees. Sunny weather predominates during the warmer season, but interruptions in the form of clouds and showers do occur—usually in the afternoons and evenings. A few days of really hot weather in July and August occur at times, but hot days are seldom oppressive because usually they are accompanied by low humidity. The warmest temperature ever recorded in Glasgow is 113 degrees, which occurred in July 1900.

As is usually the case with a "continental" type climate in northern latitudes, the change from summery to wintry weather in the fall at Glasgow is usually quite rapid, as is the change from wintry weather in the spring.

ZONE 10: The Great Plains
GLASGOW, MONTANA
Station Data

Latitude: 48°13′N
Longitude: 106°37′W
Time Zone: Mountain
Elevation: 2284′

TABLE 1: Daily Solar Data (*mean*)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	4403	7618	12540	16888	20743	23232	24888	21142	15212	9957	5433	3794	13821
Direct Beam Normal Incidence *(KJ/M²-Day)*	13676	17635	22674	26633	31311	34191	35630	32751	26993	21234	14756	12237	24160
Total Horizontal Insolation *(BTU/FT²-Day)*	388.0	671.3	1104.9	1488.1	1827.7	2047.1	2193.0	1862.9	1340.4	877.4	478.7	334.3	1217.8
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1206	1556	2000	2349	2762	3016	3143	2889	2381	1873	1302	1079	2131
Total South Wall Insolation *(BTU/FT²-Day)*	690	912	1061	919	812	771	865	1013	1114	1132	821	594	892
Percent of Possible Sunshine	44	54	58	59	61	63	74	73	64	56	44	43	58
Mean Cloud Cover	7.3	7.1	7.0	7.1	6.7	6.1	4.5	4.6	5 7	6.2	7.1	7.2	6.4
Percent of Total Horizontal to Extraterrestrial Insolation	47.4	51.7	54.9	55.7	58.3	60.5	63.7	63.3	60.3	56.7	49.3	45.9	58.0

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	9.2	15.2	25.2	42.8	54.2	62.0	70.5	69.0	57.2	46.4	29.0	17.1	41.5
Average Daily Maximum	18.9	25.4	35.6	55.0	66.7	73.9	84.3	83.0	70.4	59.2	39.1	26.5	53.2
Average Daily Minimum	-0.5	5.0	14.8	30.6	41.7	50.1	56.6	54.9	44.0	33.6	18.9	7.6	29.8
Winter/Summer Design	-18						89						

Total Heating Deg-Days for Month	1730	1394	1234	666	344	151	15	30	263	577	1080	1485	8969
Total Cooling Deg-Days for Month	0	0	0	0	9	61	185	154	29	0	0	0	438
Percent Relative Humidity *(Night)*	70	77	74	68	62	66	59	52	61	63	74	76	67
Wind Direction													
Wind Speed *(MPH)*	10.9	10.3	11.5	13.0	11.9	11.2	10.5	11.1	11.1	10.8	9.9	9.8	11.0

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

*(To find Total Solar Radiation on a Tilted Surface add the figure from **TABLE 3a.** to that of **TABLE 3b.**)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

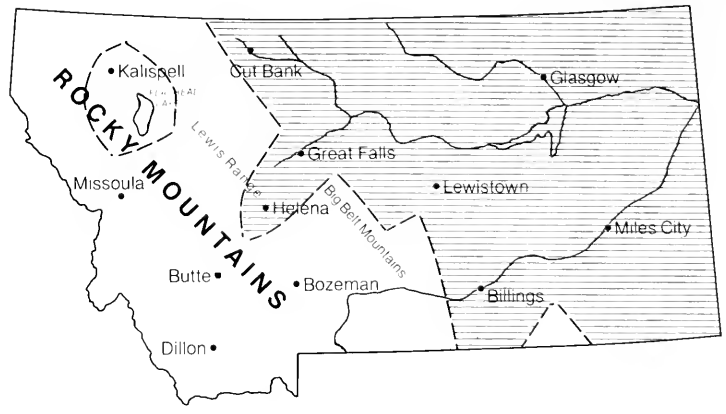
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	532	851	1294	1608	1894	2094	2270	1999	1532	1105	649	457	1357
	30	646	983	1409	1639	1957	2022	2214	2017	1634	1267	784	554	1419
	45	722	1058	1443	1579	1718	1834	2029	1917	1640	1354	873	619	1399
	60	756	1071	1393	1431	1486	1555	1728	1706	1551	1360	910	649	1300
	75	745	1021	1263	1206	1177	1191	1331	1397	1371	1284	892	640	1127
	90	690	912	1061	919	812	771	865	1013	1114	1132	821	594	892
45° ORIENT	15	487	794	1232	1562	1861	2065	2229	1947	1468	1031	595	419	1307
	30	559	875	1293	1563	1808	1981	2156	1933	1517	1130	679	480	1331
	45	599	907	1291	1493	1680	1820	1992	1830	1495	1165	725	515	1293
	60	606	887	1216	1350	1480	1585	1742	1638	1389	1132	729	521	1190
	75	579	823	1088	1154	1228	1295	1428	1383	1223	1043	693	494	1036
	90	520	714	900	913	940	974	1075	1076	995	894	617	448	839
90° ORIENT	15	383	660	1081	1453	1781	1997	2136	1815	1311	861	468	330	1190
	30	371	625	1032	1372	1672	1870	1997	1710	1244	826	452	320	1125
	45	351	599	960	1257	1522	1694	1811	1561	1152	776	425	303	1034
	60	322	547	862	1113	1337	1481	1584	1376	1028	706	391	278	919
	75	282	473	741	944	1121	1235	1322	1161	883	610	340	243	780
	90	236	394	606	755	887	972	1040	924	717	506	285	203	627

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	4	5	6	7	7	6	5	3	2	1	4
	30	5	9	15	20	24	27	29	25	18	12	6	4	16
	45	11	20	32	44	54	60	64	55	39	26	14	10	36
	60	19	34	55	74	91	102	110	93	67	44	24	17	61
	75	29	50	82	110	135	152	163	138	99	65	36	25	90
	90	29	67	110	149	183	205	219	186	134	88	48	33	122

ZONE 10: The Great Plains
GREAT FALLS, MONTANA
Station Summary



The city of Great Falls is located astride the main stem of the Missouri River at its confluence with the Sun River, while the Weather Service Office is located at the Municipal Airport on a plateau between the Sun and Missouri Rivers. This plateau is about 200 feet higher than most of the immediate valley area, and the airport is about two miles southwest of the Sun and Missouri River Junction. Except to the north and northeast, the valley is encircled by mountain ranges, which lie about 30 miles away from east to south, 40 miles to the southwest, and 60 to 100 miles distant from west to northwest. Topography plays an important part in Great Falls' climate. The Continental Divide to the west, and Big and Little Belt Ranges to the south, are primary factors in producing the frequent wintertime "chinook" winds observed in this part of Montana. The valley-plateau combination in the immediate area contributes quite often to marked temperature differences between airport and City proper, either on calm, clear mornings, or when "chinook" winds appear at the airport before they are felt at the lower elevations in town.

Summertime in the area generally is quite pleasant, with cool nights, moderately warm and sunny days, and very little weather that can be called hot or humid. Most summer rainfall occurs in showers or thundershowers, but steady rains may occur during late spring or early summer. Most summers pass with the highest temperatures failing to reach 100°, and an average year will have only 15 days with maximums 90° or higher. At the airport Weather Office, freezing temperatures do not occur in July or August, very rarely in June, and are observed only on two or three days in the usual May or September. Frost occurs frequently in April and October, but more often in the valleys than on the surrounding hills or plateau. However, frost may occur on rare occasions in nearby low lying areas at any time of the year.

Winters are not so cold as is usually expected of a continental location at this latitude, largely as a result of the "chinook" winds for which this area is noted. While sub-zero weather is experienced normally several times during a winter, the coldest weather seldom lasts more than a few days at a time, and is usually terminated by southwest "chinook" winds which can produce sharp temperature rises of 40° or more in 24 hours. As a result of recurring "chinooks" throughout the winter season, snow seldom lies on the ground for more than a few days. In fact, the ground usually is bare, or nearly bare of snow, most of the winter, except in the surrounding mountains and higher foothills. On the other hand, invasions of cold air from the polar regions occur a few times each winter, and sharp temperature falls from above freezing to below zero within 24 hours are observed occasionally from mid-December to March.

Precipitation generally falls as snow during late fall, winter, and early spring, although rain can occur in any month. Late spring, summer and early fall precipitation is almost always rain, but some hail is observed occasionally during summer thundershowers.

Although Great Falls' average annual precipitation would normally classify the area as semi-arid, it is important to note that about 70 percent of the annual total falls normally during the April-September growing season. The combination of ideal temperatures during the peak of the growing season, long hours of summer sunshine, and nearly 10 inches of precipitation during the six critical months, makes the climate very favorable for dryland farming. Heavy fog seldom occurs, incidence usually being limited to about one day per month, but each case lasts only a small part of the day. Although the average windspeed is relatively high, extremely strong winds (over 70 mph) seldom are observed, and visibility normally is excellent (15 miles or more).

ZONE 10: The Great Plains
GREAT FALLS, MONTANA
Station Data

Latitude: 47°29′N
Longitude: 111°22′W
Time Zone: Mountain
Elevation: 3662′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	4772	8173	13283	16895	20968	23849	26432	21937	15444	10493	5647	3815	14326
Direct Beam Normal Incidence *(KJ/M²-Day)*	13676	17275	21954	25913	30592	33831	36350	32751	26993	21234	14756	12597	24038
Total Horizontal Insolation *(BTU/FT²-Day)*	420.5	720.2	1170.4	1488.7	1847.6	2101.4	2329.0	1933.0	1378.5	924.6	497.6	336.2	1262.3
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1206	1524	1937	2286	2698	2984	3206	2889	2381	1873	1302	1111	2120
Total South Wall Insolation *(BTU/FT²-Day)*	741	981	1122	902	805	770	882	1032	1129	1186	827	561	912
Percent of Possible Sunshine	49	57	68	63	64	65	81	78	67	61	46	46	64
Mean Cloud Cover	7.3	7.4	7.2	7.4	6.9	6.5	4.0	4.6	5.7	6.3	7.2	7.2	6.5
Percent of Total Horizontal to Extraterrestrial Insolation	48	50	54	54	57	59	64	63	60	56	49	47	58

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	20.5	26.6	30.5	43.4	53.3	60.8	69.3	67.4	57.3	48.3	34.6	26.5	44.9
Average Daily Maximum	29.3	35.9	40.4	54.5	65.0	72.1	83.7	81.8	70.0	59.4	43.4	34.7	55.9
Average Daily Minimum	11.6	17.2	20.6	32.3	41.5	49.5	54.9	53.0	44.6	37.1	25.7	18.2	33.8
Winter/Summer Design	-15						88						

Total Heating Deg-Days for Month	1380	1075	1070	648	367	162	18	42	260	524	912	1194	7652
Total Cooling Deg-Days for Month	0	0	0	0	0	36	151	116	29	7	0	0	339
Percent Relative Humidity *(Night)*	65	65	61	60	59	59	48	47	57	58	63	65	59
Wind Direction	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW
Wind Speed *(MPH)*	15.8	14.9	13.5	13.2	11.5	11.4	10.3	10.5	11.7	13.7	15.0	16.0	13.1

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

*(To find Total Solar Radiation on a Tilted Surface add the figure from **TABLE 3a.** to that of **TABLE 3b.**)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

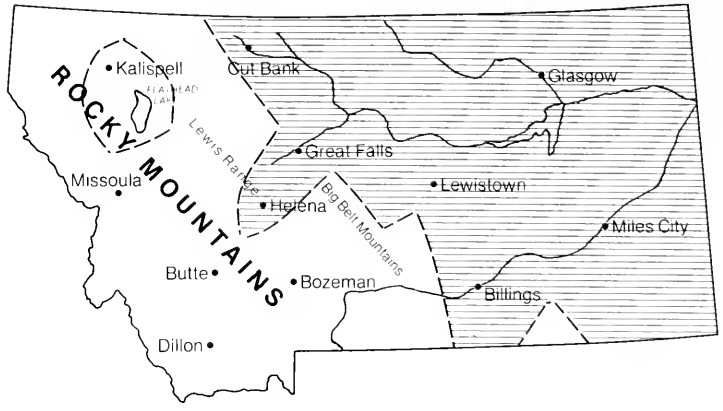
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	574	916	1373	1604	1913	2148	2412	2073	1572	1165	668	449	1406
	30	697	1059	1496	1630	1872	2072	2351	2091	1674	1336	802	538	1468
	45	779	1140	1533	1566	1729	1880	2150	1984	1678	1427	889	596	1446
	60	814	1154	1479	1416	1491	1584	1821	1761	1583	1431	923	620	1340
	75	801	1100	1339	1189	1176	1206	1389	1436	1396	1349	902	608	1158
	90	741	981	1122	902	805	770	882	1032	1129	1186	827	561	912
45° ORIENT	15	526	853	1306	1559	1880	2119	2368	2019	1507	1087	614	414	1354
	30	603	942	1371	1557	1825	2030	2288	2004	1556	1191	698	469	1378
	45	646	976	1370	1483	1693	1862	2111	1895	1530	1227	742	499	1336
	60	652	955	1290	1338	1489	1618	1841	1693	1419	1191	743	501	1227
	75	622	885	1152	1141	1232	1318	1503	1425	1247	1095	703	477	1067
	90	557	767	951	901	940	987	1124	1104	1012	937	624	426	861
90° ORIENT	15	413	708	1144	1453	1802	2049	2267	1883	1348	908	487	332	1233
	30	400	681	1091	1371	1691	1918	2116	1772	1278	870	469	321	1165
	45	377	642	1014	1255	1539	1735	1917	1615	1181	817	440	302	1070
	60	347	585	909	1110	1349	1514	1673	1421	1053	741	405	276	949
	75	202	507	782	940	1130	1261	1394	1197	903	640	351	240	804
	90	253	422	639	751	893	990	1094	951	732	530	293	201	646

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	4	5	6	7	8	7	5	3	2	1	4
	30	6	10	16	20	25	28	31	26	18	12	7	5	17
	45	12	21	34	44	54	62	68	57	40	27	15	10	37
	60	21	36	58	74	92	105	116	97	69	46	25	17	63
	75	31	53	87	110	137	156	173	143	102	69	37	25	94
	90	42	72	117	149	185	210	233	193	138	92	50	34	126

ZONE 10: The Great Plains
HELENA, MONTANA
Station Summary



Helena is located on the south side of an intermountain valley bounded on the north and east by the Big Belt Mountains and on the west and south by the main chain of the Continental Divide. The valley is approximately 25 miles in width from north to south and 35 miles long from east to west. The average height of the mountains above the valley floor is about 3,000 feet. The climate of Helena may be described as modified continental. Several factors enter into modifying continental climate characteristics. Some of these are invasion by Pacific Ocean airmasses, drainage of cool air into the valley from the surrounding mountains, and the protecting mountain shield in all directions which makes temperature changes somewhat smaller than those expected of a true continental climate.

The mountains to the north and east sometimes deflect shallow masses of invading cold arctic air to the east. Following periods of extreme cold, when the return circulation of maritime air has brought warming to most of the eastern part of the state, cold air may remain trapped in the valley for several days before being replaced by warmer air. During these periods of transition from cold-to-warm temperatures, inversions are often quite pronounced. Occasionally, temperatures in the center of the City, 200 feet higher, may be several degrees warmer than at the airport. This is noted mostly just before the invading warmer air reaches the valley floor, although there are times when the warm air will not reach the airport even after having reached the City.

As may be expected in a northern latitude, cold waves may occur from November through February, with temperatures occasionally dropping to zero or lower. The greatest number of days with zero or colder temperature can be expected during January. The greatest drop in temperature during a cold wave occurred on December 14-15, 1924, when the temperature fell 79° from a high of 63° at 2:00 p.m. on the 14th to −16° 24 hours later, finally reaching a low of −25° at midnight on the 15th. Generally the protection afforded by the mountains helps to prevent such extreme falls. Twenty-four hour changes seldom exceed 40°. There are about 161 days, on the average, between the last date of a minimum of 28° in the spring and the first in the fall. The average dates of these occurrences are April 27 and October 5. The same dates for 32° occurrences are May 12 and September 23.

Summertime temperatures are moderate, with maximum readings generally under 90° and very seldom reaching 100°. The highest ever observed was 105° on August 24, 1969. Like all mountain stations, there is usually a marked change in temperature from day to night. During the summer this tends to produce an agreeable combination of fairly warm days and cool nights.

Total precipitation varies widely throughout the valley, from a semi-arid total of 9 to 10 inches in the drier northern and eastern portions of the valley to a subhumid 30 inches along the Continental Divide to the southwest. Most of the precipitation falls from April through July from frequent showers or thundershowers, but usually with some steady rains in June, the wettest month of the year. Late summer, fall, and winter months are relatively dry. April-September growing season precipitation varies considerably, but the average is about 8 inches.

Thunderstorms are rather frequent from May through July with the maximum occurrence in July. Snow can be expected from September through May, but amounts during the spring and fall are usually light, and snow on the ground ordinarily lasts only a day or two. During the winter months snow may remain on the ground for several weeks at a time. There is little drifting of snow in the valley, and blizzard conditions are very infrequent.

In winter, hours of sunshine are more than would be expected at a mountain location. Considering the entire period of record, the average percent of possible sunshine December through February is 48 percent, and 100 percent of possible on the coldest days is rather common.

Due to the sheltering influence of the mountains, Foehn (Chinook) winds are not as pronounced as might be expected for a location on the eastern slopes of the Rocky Mountains. Strong winds can occur at any time throughout the year, but generally don't last more than a few hours at a time.

ZONE 10: The Great Plains

HELENA, MONTANA

Station Data

Latitude: 46°36′N
Longitude: 112°00′W
Time Zone: Mountain
Elevation: 3828′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	4760	8044	13000	16874	21111	23149	26486	21906	16030	10512	5915.0	4135.0	14327
Direct Beam Normal Incidence *(KJ/M²-Day)*	13316	17275	21954	26273	30592	33831	36350	32751	27352	21954	15116	12237	24146
Total Horizontal Insolation *(BTU/FT²-Day)*	419.4	708.8	1145.5	1486.8	1860.2	2039.8	2333.8	1930.2	1412.5	926.3	521.2	364.4	1262.4
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1175	1524	1937	2317	2698	2984	3206	2889	2473	1937	2317	2381	2130
Total South Wall Insolation *(BTU/FT²-Day)*	685	911	1053	880	792	739	857	1005	1134	1136	835	596	885
Percent of Possible Sunshine	47	55	61	58	61	62	80	75	67	61	45	43	61
Mean Cloud Cover	7.5	7.4	7.3	7.3	6.8	6.4	3.9	4.4	5.5	6.1	7.3	7.5	6.4
Percent of Total Horizontal to Extraterrestrial Insolation	46.8	50.6	53.5	54.9	57.9	59.9	64.5	63.6	60.9	57.4	49.0	45.5	57.7

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	18.1	25.4	30.6	42.7	52.2	59.2	67.9	66.2	55.5	45.3	31.7	23.3	43.2
Average Daily Maximum	28.3	35.8	41.7	55.2	64.8	71.6	83.7	82.0	70.0	58.7	42.6	33.2	55.6
Average Daily Minimum	7.8	14.9	19.4	30.2	39.5	46.7	52.1	50.4	40.9	31.9	20.8	13.3	30.7
Winter/Summer Design	-16						88						

Total Heating Deg-Days for Month	1454	1109	1066	669	401	194	33	57	304	611	999	1293	8190
Total Cooling Deg-Days for Month	0	0	0	0	0	20	123	94	19	0	0	0	256
Percent Relative Humidity *(Night)*	68	68	64	60	58	60	49	49	59	63	71	69	61
Wind Direction	W	W	W	W	W	W	W	W	W	W	W	W	W
Wind Speed *(MPH)*	7.1	7.7	8.7	9.4	9.0	8.7	7.9	7.6	7.6	7.4	7.2	7.0	7.9

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

(To find Total Solar Radiation on a Tilted Surface add the figure from ***TABLE 3a.*** *to that of* ***TABLE 3b.****)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

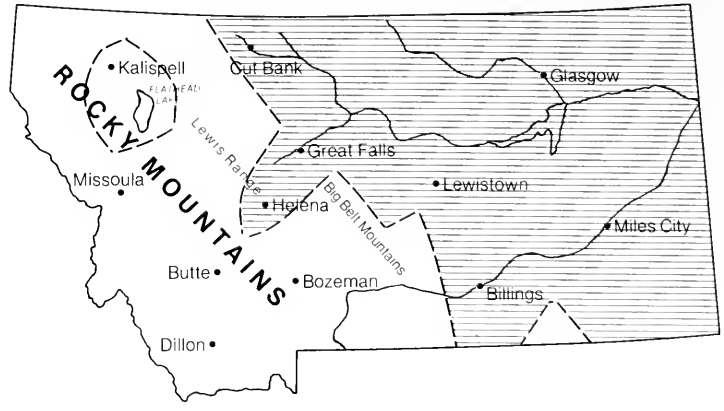
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	557	886	1329	1595	1921	2078	2410	2062	1606	1151	692	484	1398
	30	665	1012	1437	1616	1877	1999	2343	2072	1705	1309	824	577	1453
	45	736	1080	1463	1547	1728	1810	2135	1960	1704	1388	909	628	1425
	60	763	1085	1403	1394	1486	1523	1802	1734	1603	1385	940	662	1315
	75	746	1027	1263	1167	1167	1157	1366	1408	1408	1299	915	647	1131
	90	685	911	1053	880	792	739	857	1005	1134	1136	835	596	885
45° ORIENT	15	513	829	1269	1552	1890	2051	2368	2010	1541	1078	637	446	1349
	30	581	906	1323	1546	1831	1962	2284	1989	1587	1172	720	504	1367
	45	616	932	1314	1469	1695	1795	2102	1876	1557	1201	761	535	1321
	60	616	905	1232	1321	1488	1557	1828	1671	1441	1159	759	536	1209
	75	583	834	1095	1124	1227	1265	1487	1402	1262	1061	715	508	1047
	90	519	718	900	884	934	946	1107	1083	1021	901	632	453	842
90° ORIENT	15	411	698	1121	1451	1814	1989	2272	1880	1381	909	510	358	1233
	30	396	669	1068	1369	1702	1861	2119	1767	1307	869	490	346	1164
	45	372	629	990	1251	1547	1683	1917	1609	1207	813	459	325	1067
	60	341	571	885	1104	1355	1467	1671	1413	1074	735	420	297	944
	75	295	493	759	933	1133	1220	1330	1188	920	634	363	258	799
	90	246	409	618	744	894	956	1089	941	744	523	302	215	640

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	4	5	6	7	8	7	5	3	2	1	4
	30	6	9	15	20	25	27	31	26	19	12	7	5	17
	45	12	21	34	44	54	60	68	57	41	27	15	11	37
	60	21	35	57	74	93	102	117	96	71	46	26	18	63
	75	31	53	85	110	138	151	173	143	105	69	39	27	94
	90	42	71	115	149	186	204	233	193	141	93	52	36	126

ZONE 10: The Great Plains
LEWISTOWN, MONTANA
Station Summary



Lewistown is situated among rolling foothill country in a mountainous area of Central Montana. The largest nearby mountain, Big Snowy, rises to an elevation of 8,800 feet about 15 miles due south of the city, while the Judith Mountains, with several peaks higher than 6,000 feet, start about 5 miles northeast. To the northwest about 7 miles are the South Moccasin Mountains, with highest elevations under 6,000 feet. As will be seen, this location in mountainous country has a rather marked effect on climate in the Lewistown area. Big Spring Creek flows generally northwestward around the eastern edge of the city, and joins the northward-flowing Judith River about 12 miles to the northwest. Small differences in day-to-day weather in Lewistown and around the airport are often observed, due largely to the hilly nature of the area. The airport elevation, 4,132 feet, where observations have been recorded since late in 1939, is about 200 feet above most of the city.

While Lewistown is located about 150 miles east of the Continental Divide, it actually lies north and west of mountains large enough to influence local weather far more than the main chain of Northern Rockies. Prevailing winds are from the westerly quadrant, and much of the time the air borne on these winds has traveled over the Continental Divide from Pacific Ocean source regions. Instead of being downslope in the Lewistown area, however, these winds in Western Fergus County become upslope due to the mountains in the easterly quadrant. The climate of Lewistown can be described as modified continental in character, the mountains helping to separate the area from the more representative continental climate zones to the east. As a whole, Lewistown climate is representative only of the limited area at the base of the foothills of the two nearby groups of mountains.

Precipitation in the Lewistown section runs higher by several inches a year than most locations East of the Divide in Montana, and it is an unusual season when growing season rainfall is light enough to be insufficient for dryland crops such as grains. Of the 17.32-inch average for the 1926-1955 period, 8.34 inches—or nearly half—has fallen during the three main growing months May, June, and July. Winter precipitation generally is light, all months November-March averaging less than one inch of moisture, but nearly all winter moisture falls as snow, rain seldom being observed in December, January, or February. Heaviest snowfall months, on the average, are December and March. Temperature differences in hilly country such as that around Lewistown can be as large as several degrees, particularly on clear, still winter mornings when valley bottoms can be 10°F or more colder than surrounding hillsides. Summer weather is seldom hot, although maximum readings may reach 90° or more on 14 days in an average year. Usual summertime afternoon temperatures range in the low or mid-eighties, while morning lows, around sunrise, most of the time run between 45° and 50°. Oppressive heat is rare. Sunny weather is common during the warm season, but is subject to interruption at times from showers or thundershowers, mostly in the afternoon or early evening. In the surrounding farming sections hailstorms occur somewhere almost every year, but damage to crops therefrom is usually rather localized, and damage to property usually is light. Strong winds are observed occasionally at the airport about 2 miles west of the city center, but velocities are almost always lower in town.

Winters are cold, but here the modifying influence of the mountains makes itself felt in that midwinter cold is not generally as severe or persistent as in the true or unmodified continental climate. Winter cold spells do occur, but seldom last more than a few days without a break in the form of warmer winds from westerly directions. In midwinter, heavy snowstorms are rare, but up to 12 or 13 inches in a day have fallen in February, March, and April. The seasonal transition from winter to spring and from fall to winter is usually rapid.

ZONE 10: The Great Plains

LEWISTOWN, MONTANA

Station Data

Latitude: 47°03′N
Longitude: 109°27′W
Time Zone: Mountain
Elevation: 1264′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	4766	7856	12806	16391	20508	23368	25964	21580	15570	10271	5701	4120	14075
Direct Beam Normal Incidence *(KJ/M²-Day)*	10437	14036	19075	24473	30232	33831	36350	33111	27352	20154	11517	8638	22465
Total Horizontal Insolation *(BTU/FT²-Day)*	420.0	692.2	1128.4	1444.3	1807.0	2059.0	2287.8	1901.5	1372.3	905.0	502.3	363.0	1240.2
Direct Beam Normal Incidence *(BTU/FT²-Day)*	921	1238	1683	2159	2667	2984	3206	2921	2413	1778	1016	762	1982
Total South Wall Insolation *(BTU/FT²-Day)*	678	868	1022	847	770	740	841	985	1084	1086	775	525	857
Percent of Possible Sunshine	26	37	49	53	59	51	80	76	65	49	28	22	50
Mean Cloud Cover	8.6	8.4	8.1	7.7	6.9	6.4	3.7	4.3	5.5	6.9	8.4	8.8	7.0
Percent of Total Horizontal to Extraterrestrial Insolation	38	43	48	52	57	60	65	64	61	54	41	35	55

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	19.1	23.8	27.5	40.1	49.6	56.6	65.5	64.4	54.0	45.5	32.2	24.5	41.9
Average Daily Maximum													
Average Daily Minimum													
Winter/Summer Design	-16						87						

Total Heating Deg-Days for Month	1423	1154	1163	747	477	265	70	94	348	605	984	1256	8586
Total Cooling Deg-Days for Month	0	0	0	0	0	17	120	87	25	6	0	0	255
Percent Relative Humidity *(Night)*													
Wind Direction													
Wind Speed *(MPH)*													

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

(To find Total Solar Radiation on a Tilted Surface add the figure from ***TABLE 3a.*** *to that of* ***TABLE 3b.****)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

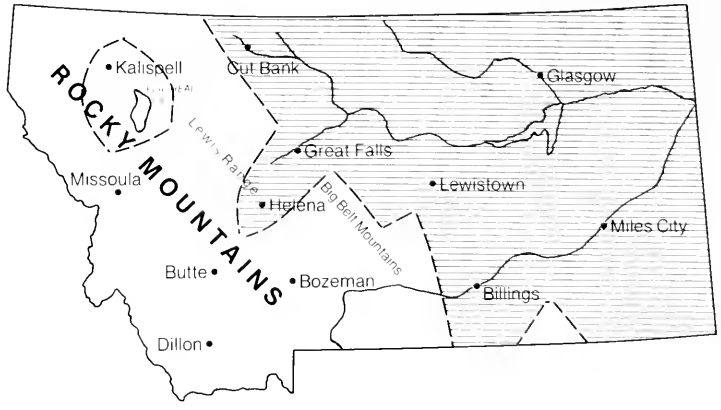
TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	556	858	1303	1544	1863	2097	2359	2029	1553	1117	657	479	1368
	30	668	975	1405	1561	1817	2017	2291	2036	1643	1264	777	570	1418
	45	731	1037	1427	1492	1672	1825	2087	1924	1638	1337	852	629	1388
	60	757	1039	1367	1343	1438	1534	1761	1700	1537	1330	878	651	1278
	75	739	981	1229	1123	1130	1164	1237	1380	1248	1244	851	636	1097
	90	678	868	1022	847	770	740	841	985	1084	1086	775	585	857
45° ORIENT	15	513	804	1245	1504	1834	2070	2319	1978	1492	1048	608	443	1322
	30	579	875	1296	1495	1775	1980	2235	1956	1532	1135	682	499	1336
	45	613	898	1285	1419	1642	1810	2055	1542	1500	1159	717	528	1289
	60	613	870	1202	1275	1440	1570	1788	1641	1385	1116	712	528	1178
	75	579	800	1068	1083	1188	1274	1454	1375	1212	1020	669	500	1018
	90	514	687	876	852	905	952	1083	1062	979	866	589	445	818
90° ORIENT	15	412	681	1103	1409	1763	2007	2228	1853	1342	888	491	357	1211
	30	397	653	1051	1329	1654	1878	2078	1742	1270	849	472	345	1143
	45	372	613	973	1215	1504	1697	1880	1585	1172	794	441	324	1048
	60	240	556	870	1072	1317	1479	1639	1392	1042	717	403	296	927
	75	295	479	746	905	1101	1230	1363	1170	892	617	348	256	783
	90	245	396	606	722	869	964	1068	927	720	508	289	213	627

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	1	2	4	5	6	7	8	6	5	3	2	1	4
	30	6	9	15	19	24	28	31	25	18	12	7	5	17
	45	12	20	33	42	53	60	67	56	40	27	15	11	36
	60	21	35	56	72	90	103	114	95	69	45	25	18	62
	75	31	51	84	107	134	153	170	141	102	67	37	27	92
	90	42	69	113	144	181	206	229	190	137	90	50	36	124

ZONE 10: The Great Plains
MILES CITY, MONTANA
Station Summary



Miles City is located on the western edge of the northern great plains in a shallow part of the Yellowstone Valley. The Tongue River runs south from its confluence with the Yellowstone just west of the city. To the north the river bluffs are from 200 to 300 feet above the valley floor. There are no nearby mountain ranges to influence climatic conditions. Temperatures range from very cold in winter to quite warm in summer, which is characteristic of continental locations. Annual rainfall averages about 13 inches a year, and the climate is classed as semi-arid with less than 10 inches about one year in seven.

The temperature has ranged from a low of −65°, at Fort Keogh 3 miles southwest of the present City, on January 13, 1888, to a high of 111° on July 31, 1901. Cold waves accompanied by temperatures of zero or lower occur frequently during the winter, are usually accompanied by northerly winds and snow, and last from two to four days. Periods of several days with minimums of zero or lower can be expected during the winter months, and the longest period of record, 33 days, occurred January 9 to February 10, 1916. Spring and fall are cool with maximum temperatures of 90° or above rarely occurring as early as April or as late as October. Zero readings have been reported as late as April 1 and as early as October 28. Maximum temperatures of 90° or more occur frequently in July and August, but as to be expected in a semi-arid region, humidities are low and the heat is not as oppressive as would be expected from such warm temperatures. From July 14 through August 1, 1936, there were 19 consecutive days with temperatures of 90° or above. At the observation station in the City proper from July 13 through August 6, 1951, there were 25 consecutive days in that range.

About 70 percent of the precipitation falls during the growing season, April through September, with greatest monthly amounts usually falling during May and June. Precipitation during the spring and summer often falls during periods of shower or thunderstorm activity; however, general rains also are frequent in late spring and early summer. Measurable snowfall can be expected as late as May and as early as September.

Killing freezes have been reported as late as the last week in May and as early as the first week of September, but generally do not occur after the last week in April or earlier than the first week of October. The growing season averages about 158 days. Sunny growing seasons, with May and June rainfall being the heaviest of the year, encourage rapid crop development. Crops grown in this area seldom have difficulty in reaching maturity, although hail sometimes causes local damage during the middle of the summer.

ZONE 10: The Great Plains
MILES CITY, MONTANA
Station Data

Latitude: 46°26′N
Longitude: 105°52′W
Time Zone: Mountain
Elevation: 2629′

TABLE 1: Daily Solar Data *(mean)*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Total Horizontal Insolation *(KJ/M²-Day)*	5787	8458	13449	17500	21515	24353	26022	22437	16386	10903	6254	4532	14750
Direct Beam Normal Incidence *(KJ/M²-Day)*	15476	18355	23034	27352	31671	34550	35630	33111	28072	22674	16555	14756	25183
Total Horizontal Insolation *(BTU/FT²-Day)*	457.0	745.0	1185.0	1542.0	1895.0	2145.8	2292.9	1977.0	1443.0	960.7	537.1	399.3	1299.7
Direct Beam Normal Incidence *(BTU/FT²-Day)*	1365	1619	2032	2413	2794	3048	3143	2921	2476	2000	1460	1302	2222
Total South Wall Insolation *(BTU/FT²-Day)*	783	977	1098	914	801	758	842	1025	1162	1195	907	687	929
Percent of Possible Sunshine	51	55	59	62	63	68	77	78	69	64	50	53	62
Mean Cloud Cover	6.8	7.0	6.9	6.8	6.5	5.5	4.0	4.0	5.1	5.4	6.6	6.5	5.9
Percent of Total Horizontal to Extraterrestrial Insolation	50.9	52.8	55.6	57.4	59.3	62.2	64.4	64.0	61.8	59.2	52.7	50.9	59.4

TABLE 2: Climate Data

TEMPERATURE (°F)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
Average Monthly	15.4	21.6	30.2	45.3	56.3	64.9	74.4	72.5	59.9	48.8	32.4	22.0	45.3
Average Daily Maximum	26.1	32.8	41.6	57.8	68.9	77.4	88.9	87.2	73.5	62.1	43.1	32.2	57.6
Average Daily Minimum	4.7	10.4	18.7	32.7	43.6	52.3	59.8	57.7	46.2	35.5	21.7	11.7	32.9
Winter/Summer Design	-15						95						

Total Heating Deg-Days for Month	1538	1215	1079	591	288	117	9	16	217	508	978	1333	7889
Total Cooling Deg-Days for Month	0	0	0	0	19	114	301	248	64	6	0	0	752
Percent Relative Humidity *(Night)*	73	78	74	69	67	65	53	48	61	64	75	76	67
Wind Direction	NW	NW	NW	NW	SE	SE	SE	SE	NW	SSE	SSE	SSE	SE
Wind Speed *(MPH)*	9.5	9.5	10.7	11.7	11.0	10.2	9.6	9.6	9.9	9.8	9.8	9.7	10.1

TABLE 3: Daily Solar Radiation on Tilted Surfaces

(Calculated Values) *(Engineering Units [BTU/FT²-Day])*

*(To find Total Solar Radiation on a Tilted Surface add the figure from **TABLE 3a.** to that of **TABLE 3b.**)*
(Reflectivity = 0.2) (Multiply values by [RHO/0.2] for other reflectivities)

TABLE 3a: Direct Beam+Diffuse

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
0° ORIENT	15	619	938	1380	1658	1960	2189	2365	2115	1645	1201	739	540	1446
	30	747	1077	1475	1682	1914	2107	2296	2127	1749	1970	886	652	1508
	45	831	1153	1524	1612	1762	1905	2092	2012	1749	1456	981	726	1484
	60	866	1161	1463	1453	1513	1599	1765	1778	1646	1455	1017	757	1373
	75	850	1101	1318	1215	1186	1207	1339	1441	1445	1366	992	744	1184
	90	783	977	1098	914	801	758	842	1025	1162	1195	907	687	929
45° ORIENT	15	568	876	1315	1612	1928	2159	2325	2061	1578	1123	680	496	1393
	30	648	961	1374	1607	1867	2066	2240	2040	1626	1224	771	566	1416
	45	692	992	1367	1528	1728	1889	2060	1924	1597	1256	818	605	1371
	60	695	965	1282	1375	1516	1637	1792	1714	1478	1214	818	609	1258
	75	660	891	1141	1169	1249	1327	1457	1436	1295	1113	772	579	1091
	90	589	768	937	919	949	939	1086	1108	1047	947	683	518	878
90° ORIENT	15	448	733	1158	1504	1849	2092	2232	1925	1412	943	539	393	1269
	30	433	704	1104	1418	1734	1955	2083	1809	1336	902	518	380	1198
	45	407	661	1023	1296	1576	1766	1884	1646	1233	844	486	357	1098
	60	373	601	915	1144	1380	1539	1642	1446	1097	763	445	327	973
	75	324	519	785	966	1154	1279	1366	1215	940	658	385	285	823
	90	271	431	639	770	910	1001	1070	962	760	543	321	238	660

TABLE 3b: Reflected

	TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ANY° ORIENT	15	2	3	4	5	6	7	8	7	5	3	2	1	4
	30	6	10	16	21	25	29	31	26	19	13	7	5	17
	45	13	22	35	45	56	63	67	58	42	28	16	12	38
	60	23	37	59	77	95	107	115	99	72	48	28	20	65
	75	34	55	88	114	141	159	170	147	107	71	41	30	96
	90	46	74	118	154	190	215	229	198	144	96	55	40	130

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